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E. J. REED, Esq., C.B., M.P., AND DOCK EXPANSION IN THE WEST.

THE extraordinary development of the mineral resources of South Wales, and of all kinds of trade in consequence, has been followed up by a very large and remarkable increase of dock accommodation in the British Channel. In Bristol itself the dockization of the Avon has long been a favourite scheme, and the great works at the mouth of the tidal river deserve special attention. At Newport the large Alexandra Dock, which has already occupied years in construction, is approaching completion. The greatest docks of all are at Cardiff, whose gates are the largest in the world, and can be opened by a lady's hand; and although the large new dock accommodation will be opened in a few weeks, it is already foreseen that this will be insufficient for the requirements of the districts; and Lord Bute, the proprietor, has come before the present Parliament to acquire new powers for fresh works. At Swansea there is incessant activity. The new docks at Neath and Briton Ferry are in full operation. Even in the furthermost West, the long-neglected region of Milford Haven—thanks mainly to the energy of Mr. E. J. Reed, the member for the Pembroke boroughs—there are unwonted signs of stir and bustle. The difficult relations between capital and labour may retard the rate of progress, and, most alarming symptom of all, may frighten away buyers from the district, but, up to the present point, the dock expansion, following upon the general activity of trade, has been most satisfactory, and despite some unfortunate auguries, we will trust of good promise for the future.

We will commence with the extreme west of Pembrokeshire. Milford Haven has always had magnificent expectations attached to it. In the past it really was of the greatest importance, but the people of "the little England beyond Wales" have always hoped for a future that should transcend the past. Shakespeare makes Imogen say—

> "How far is it
> To this blessed Milford? And, by the way,
> Tell us how Wales was made so happy as
> To inherit such a haven."

In these days Milford was a great port for the Continent, and, when no Liverpool existed, the highroad to Ireland. The fond imagination has been that the Pembroke docks may one day be as important as the Liverpool docks. Milford is a day's rail nearer to America than Liverpool, and saves the intricate navigation of St. George's Channel. Cromwell made Milford his chief station for Ireland and the Continent. Lord Nelson pointed out its peculiar advantages as a great naval depot. In the Queen's "Journal" her Majesty describes herself and the Prince as greatly delighted with it. And, indeed, there is hardly such a harbour in the world. All the fleets of Europe might repose on its bosom, and its land-locked waters repose in perfect quietude whatever storms may rage without. "Rio and San Francisco may rival it, but do not surpass it. Cork and Naples are no more to be compared with it than the Wye is with the Thames as a navigable river."

We are glad to find that there are signs of revival at Pembroke Dock, or Pater, as the people oddly call it. Although the dock looks large and imposing enough as you come down the hill, in the old days the nearer prospect always brought considerable disappointment. Mr. Reed convinced the Board of Admiralty a short time ago that the works required a larger number of hands, and there is an influx of some hundred additional labourers. The Pennar Shipbuilding Company have now established their works at Pembroke Dock, or, to speak more accurately, at Jacob's Pill, Pennar, between Pembroke and Milford Haven; and the Pennar Shipbuilding Company mainly means Mr. Reed himself. His new plan of the Pennar works was the result of a design formed years ago. Mr. Reed recently mentioned that it was "on the peaceful plains of Egypt and within the shadow of the Pyramids" themselves that he formed his design. He has now entirely abandoned the Hans Shipbuilding Yard at Hull, to devote himself exclusively to Pembroke Dock. There has been an enormous capital sunk in providing the appliances for the Pembroke Dockyard, and yet for the last five years it has not been used to half the extent that it ought to have been, and so one-half of a large capital has been wasted. Mr. E. J. Reed seems to be the magician who is to awake the haven and dockyard into life.

Docks will very shortly be commenced at Milford Haven. The Great Western Railway Company have voted £50,000 towards this object. A sea-wall is to be built from Halkin Point to Milford, forming a long floating dock of what is now called Hubberstone Peb. Outside of this a graving-dock, capable of accommodating the largest vessels, is to be constructed, towards which it is understood that the Government has promised considerable assistance.

On any paper relating to dockyards, that great authority, Mr. Reed, is entitled to mention, and, as we have seen, he has a special place in this paper. A few words respecting him will have their own interest. There are some points in his career which are full of encouragement for industrial genius and perseverance. He was only a lad when he was examined by that quick-sighted and remarkable man, the late Canon Moseley, in a competitive examination ordered by Government, and selected to undergo a special training in the School of Mathematics and Naval Construction at Portsmouth; he was then thanked by Admiral Price for his exemplary conduct during his four years' study at the Sheerness Dockyard School. At the Portsmouth school he held a high position, and was specially recommended by its principal, Dr. Woolley, as being peculiarly qualified for advancement in her Majesty's service. The Government, however, entirely abolished the establishment, instead of promoting its principal *alumnus*. He was content to serve for a year as draughtsman in the Sheerness dockyard. Finding, however, that there was little opening in the public service, he became editor of the "Mechanics' Magazine," which, under his management, became an authority on all questions of naval architecture. So great was his authority, that when the late Sir Baldwin Walker was attacked in the House of Commons, it was thought that sufficient answer was made by reading in defence one of Mr. Reed's contributions to that periodical. His great *coup*, however, was made when he read before the Society of Arts his famous paper on "The Modifications which the Ships of the Royal Navy have undergone during the present Century in Dimensions, Form, Means of Propulsion, and Powers of Attack and Defence." The striking information thus accumulated was repeatedly quoted and commented on by the leading journals. The Government of the day placed in his hands all the information they had received respecting the French navy, in order that there might be a full understanding of the relative strength of English, French, and other navies. The ultimate consequence of this connection with Government was that Mr. Reed brought before the Admiralty his proposals to reduce the dimensions, cost, and time required for building our ironclad ships of war. After he had converted some ships into ironclads, he received the office of Chief Constructor to the Navy. The chief desire of the Admiralty at this time was to increase the armour plating of frigates now known as the "Lord Warden" and "Lord Clyde" class, the conditions being that these frigates should have wooden hulls, armour plates, and a speed of thirteen knots. This problem, long supposed insoluble, was solved by Mr. Reed, with half a knot to spare. There was a wonderful amount both of economy and simplicity in Mr. Reed's plans. He wished fully to maintain our naval superiority on the high seas, and to build vessels speedily and powerfully, and at the same time his largest ships have been characterised by a cheapness hitherto unknown in shipbuilding. There was a series of splendid triumphs for Mr. Reed. The result was satisfactory in every case. The "Times" was full of congratulations. The American Government considered that its navy had been already excelled by our own.

As a scientific writer Mr. Reed has made a very considerable success. Two books especially made his reputation as an author, "Shipbuilding in Iron and Steel," and "Our Ironclad Ships." His work on "Shipbuilding in Iron and Steel" is dedicated to Sir Spencer Robertson, in acknowledgment of the many and important improvements in the construction of iron ships which have been made by his desire and under his authority. The Lords of the Admiralty resolved to employ it as the text-book upon which the examinations in practical iron shipbuilding of candidates for promotion in the dockyards will hereafter be mainly based. It is interesting to observe that in this work he gives an account of experiments on friction of riveted joints, which he caused to be made at Pembroke. This is one of the first points in his connection with Pembroke. The most remarkable feature of his career was the steady opposition which he offered to the production of ships of the Monitor class. He held that the very best of this class were only steam batteries, and not sea-going vessels, and could not make a voyage except in smooth weather. Ultimately these views became distasteful to the First Lord, but the awful catastrophe of the "Captain," however it may be explained, seems to give sad confirmatory evidence of the truth of his views.

In three years he designed ironclads for the British navy to the extent of 35,000 tons, a fleet of steam transports for the service of the Indian Government, consisting of five ships of 4,000 tons each, a paddle dispatch-steamer of war, and numerous

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tugs, life-boats, and other smaller vessels. He worked four years more, and then came the unfortunate antagonism with Mr. Childers. As we have seen, he thoroughly objected to rigged sea-going turret ships, and as these were in high favour with government, he resigned his office. He has since been engaged in private pursuits, visiting occasionally the foreign dockyards of Europe. He has had full share of foreign honours and decorations. Politics at times seem to have divided his attention with ship-building, and it appeared tolerably clear that whatever port might possess Mr. Reed as a member, would also own him as a ship-owner. Pembroke has returned him to parliament, and he now very naturally does what he can for Pembroke.

We now make a leap westward to the leading docks of South Wales. The seaport town of Cardiff is remarkable, even in these days of rapid commercial development, for the extent of its commerce and the rapidity of its growth. It has always been the titular chief town of Glamorganshire, and the ivied keep of its ancient castle, where Robert of Normandy endured his long, cruel imprisonment, has given it a mention in general history. Neither were its peculiar resources neglected or unknown a century ago. From the valleys and mountains behind the little town minerals were brought on the backs of mules and horses to the open wharf, and even exported to America about the time of the War of Independence. But from that date the old historic town has increased a thousandfold. Once it was chiefly famous to the tourist or general reader as being in the neighbourhood of the miniature cathedral city of Llandaff; but at the present time Llandaff, with its splendidly restored cathedral, is only a favourite suburb of Cardiff. The upward progress of the town has been rapid. The first point is marked by the construction, towards the end of the last century, of the Glamorganshire Canal, from Merthyr Tydvil to the sea. It dropped from lock to lock some 500 ft. in the course of its 25 miles' journey down to a certain sea-pond capable of holding vessels of 200 tons, which was considered by the Cardiffians of that day to be a marvel. This dock had only been constructed for a few years when the last Marquis of Bute came into his estates. He was a man who naturally possessed a fine commercial and financial genius. He had all the instincts of business. He had the same characteristics as the enterprising Duke of Bridgewater. The story of the Cardiff docks has been often told, but we may glance once more at its salient features, and bring it down to the new and projected improvements of the present time. The great Marquis, for he deserves that title at least as much as his illustrious ancestor the Prime Minister, held some 25,000 acres of the Glamorganshire hills teeming with mineral treasures, and he also possessed a desolate tract of moorland in front of the old-fashioned little town of Cardiff. Lord Bute's attention was often called by his mineral agent to various plans for utilizing his property. The co-operation of capitalists was invited, but such men did not see how there could be any remunerative traffic through such a limited channel as the Glamorganshire Canal. In 1830 Lord Bute obtained a bill for the construction of a dock. The question was whether the dock should be on the Cardiff moors on the east, or whether it should be on the west of the estuary formed by the rivers Taff and Ely. The former site was decided on; it was thought that the latter site would not give sufficient anchorage in bad weather to vessels of large tonnage. Had the decision been different, old Cardiff would have been completely overshadowed by a new, healthier, and more imposing town, that would have climbed the heights of Penarth. It is possible, however, that a future generation will see an ultimate expansion of the docks in this direction. An artificial stream, which, overshadowed with abundant foliage, is a feature of beauty in the town, diverts from the Taff water to fill the dock, as the Bristol Channel water is too muddy for that purpose. This West Dock, the first of the docks, has been truly called the "cradle" of the progress of Cardiff.

The difficulty was how to connect the dock, which (owing to the expanse of mud-flats covered and uncovered by the tide) was considerably above low-water mark, with the waters of the Channel. The following extracts from Captain Smyth's "Nautical Observations on the Port and Maritime Vicinity of Cardiff," will best explain how the difficulty was overcome:—It was originally intended that the sea-gates or entrance from the Bristol Channel into the Bute Ship Canal should have been placed at the Eastern Hollows, and that the entire length of the canal should be protected on each side by stone quay walls, with towing paths along which vessels were to be drawn to the wet dock, at the commencement of which another pair of gates were to be placed. The estimate for these works, which were designed by Mr. James Green, of Exeter, was £70,000; but when contracts were sought to be let, although no real engineering difficulties existed, no contractors could be found to tender for a given sum, in consequence of the unforeseen difficulties which might arise in the operation, carried on in tidal water. Under these circumstances, Mr., afterwards Sir William, Cubitt, was called in, and at his suggestion, the original ship canal was abandoned, and, in lieu thereof, an open tidal cut or entrance channel was made through the mud from the Eastern hollows to the shore, to be kept open by sluices from or near the dock gates. Vessels are now consequently towed by steam tugs, or sail up this entrance channel, instead of being tracked by land along towing paths, as originally intended. The wet dock or basin was constructed pretty nearly on the original plan, but with the addition of a sea basin with a lock between it and the dock, which became necessary on the abandonment of the ship canal with its sea gates. The old Glamorgan Canal is brought into connection with the docks.

The West Dock was opened in 1839 with great rejoicings and festivities. All the expectations formed were more than justified by the result. In a few years it became evident that more accommodation would be required. The rail was now rapidly bringing down the produce of the hills. The Taff Vale Railway had been formed, and the western side of the dock was ceded to their use on condition of bringing all their mineral trade there. This company had, however, promoted a dock, small indeed but of a rival character, below the opposite headland at Penarth. These conflicting arrangements have caused a long expensive litigation between the Taff Railway and the Bute Trustees, which terminated last year in a decision in favour of the latter, based, however, upon technical grounds. One curious result has been that in all the contemplated developments and improvements of the Marquis there has been a steady opposition on the part of the company before parliamentary committees. Indeed every individual, or body of individuals, that could attain a *locus standi* has persistently offered every possible opposition to dock development. There is no landowner the value of whose land has not been quintupled, no tradesman whose business has not been multiplied, no coal-owner whose property has not been made convertible by means of these docks. They constitute, in point of fact, an enormous endowment for the good of Cardiff and South Wales. Still, in a mode inexplicable to a bystander, the inhabitants of Cardiff have offered a persistent opposition to all suggested improvements; improvements which do not cost them a farthing, but yield them enormous benefits. It generally happens, however, that after a few years they are clamorous for improvements which they rejected a few years before. It is one of the oddest examples of municipal short-sightedness with which we are acquainted. It is only fair to say that those who oppose what is called the "Bute monopoly" adopt a different line of argument. They say that public companies would eventually have adopted, and would even now adopt, the same system of docks, and carry them out in a better way.

The enterprising Marquis died somewhat suddenly in 1848. He had seen the commencement of his great works, but with all his far-sightedness he could hardly have anticipated their enormous later development. He had determined that his great work should not be made dependent on the life of any individual. He had fully provided against the contingencies that might arise through his death. He handed over his estates to trustees for the benefit of his infant son, and for carrying out his design for making Cardiff a great sea-port. What the power of these trustees may really be is somewhat ambiguous. Nominally the trust is for fifteen hundred years, but on one occasion the chairman of the Committee of the House of Lords observed that practically it was well understood that such a trust terminated on the minor becoming of age. Mr. Boyle, the acting trustee, said that they would surrender the property as a matter of propriety but not as a matter of law, when the minor came of age, but the term of the trust under the deed did not then expire. His counsel added that in point of law the trustees after Lord Bute came of age, might apply the income of the docks to any purpose they pleased, whether Lord Bute approved or not. Lord Bute, however, even from a boy, manifested the greatest interest in the undertakings, and the highest credit is due to this young nobleman, who is contented to forego a vast annual income for the sake of promoting great public objects, the benefit of which must be reaped by another generation.

The great works of the Bute minority are soon traced. The West Dock being insufficient, it was resolved, in 1851, that the East Dock should be commenced. The South Wales Company, afterwards amalgamated with the Great Western, gave a full co-operation. It was intended that this dock should be opened in two years' time, but before that period the wants of the locality had increased so largely that a further extension, and after that a still further extension, was deemed absolutely necessary. This dock now covers forty-five acres; the width is partly 300 and partly 500 ft.; the total length is 4,300 ft.; the width of the sea lock is 55 ft.; the length between the gates is 220 ft. A careful examination of this great dock is extremely interesting. Being kindly provided with a steam-tug for the purpose, I leisurely sailed

up the length of the dock, from the basis to the South Wales Atlantic Wharf at the upper end. There were some ninety less vessels than the average in the port, owing to the prevailing strikes. Still the cosmopolitan character of Cardiff was very apparent. The flags of all kingdoms and republics seemed represented in the harbour. The official records show exportations to every part of the known world. Among the vessels was the "Pembroke," one of the new line of splendid Atlantic steamers trading direct from Cardiff to New York. This line is becoming very favourably known, and is going some way towards establishing an import business, which is the great necessity of Cardiff. There are also regular lines of steamers to different ports of Scotland, Ireland, and France. There is also regular communication with Bristol and until lately with Burnham, but the Burnham boat is now withdrawn. The import business is very much improving. Cargoes of iron ore and esparto grass from Spain are getting very common. The scenes on the wharves are those which convey the greatest idea of the extent and activity of business. There are enormous staiths for shipping coal from the waggons, in some cases hydraulic lifts being used instead of balance lifts. There are steam cranes to discharge the enormous amount of ballast which is carried away and deposited on the East Moors, at an annual expense of many thousand pounds. It is fondly hoped that the day will arrive when substantial cargoes will replace this enormous ballast. All the approaches about the docks are covered with a network of railway lines, which give direct communication from wharves and warehouses to every part of the kingdom. The South Wales railways bring down the minerals from the mouths of the pits to the water-side, and again from the water-side they may be distributed to every part of the kingdom. The network of railways is of a unique character, and presents a very curious spectacle. On every hand immense warehouses are rising. An entirely new business suburb lies to the south of the new town, the traffic being promoted by tram-lines. Everywhere in Cardiff rapidity, ease, and security are the great objects sought and obtained. There is rather an American, or more properly a cosmopolitan character peculiarly its own about the place.

In 1864 the trustees brought forward very extensive plans for enlarging the system of docks. After a week's fight in committee, the chairman laconically pronounced the decision that they thought the bill had better not be proceeded with. The real reason was that Lord Bute was a minor, and it was felt to be unfair to pledge a minor to an interminable expenditure. The trustees, however, returned undauntedly to the charge, and obtained several most important concessions. One of them was the formation of the Low Water Pier, which was opened by Lord Bute when he came of age, in 1868. This alone could enable any one to land at low water, and was essential for the working of lines of steamers. It is certain that this pier does good service as a breakwater, but it does not seem to us to have proved of as much use as was anticipated. The South Basin, however, is the new work which just now is attracting a large degree of attention. The water was admitted a few weeks ago, and it will be formally occupied in a few weeks' time. The dock sought for was not granted at the time, but this new basin will act as a dock in relieving the pressure for accommodation, and the long desiderated dock will, in all probability, be shortly commenced, and will occupy several years and cost several hundred thousand pounds in the construction. There are nine coal-tipping staiths on the basin, which largely increase the capacity for out-put.

The basin shows massive and efficient workmanship, combined with great skill and economy, and reflects the highest degree of credit on the constructor, Mr. John McConnochie, who is the engineer for Lord Bute's property. The waters of the Cardiff docks and basins hide for ever the finest and most finished workmanship. The area of the new basin occupies twelve acres, and it is connected with the East Dock by a junction lock. The walls of the basin, fifty feet high, are constructed of stone brought from Lord Bute's quarries at Pwll-y-Pant. The wrought-iron gates have a larger superficial area than any similar works ever constructed.

In 1831 the population of Cardiff, as we have already stated, amounted to 6,187. Since then it has gone on increasing in something like geometrical progression, until at the present date it has reached upwards of 70,000. Again, in 1839, when the West Bute Dock was opened, the aggregate tonnage of vessels trading to the port of Cardiff was 6,022. Nine years afterwards, in 1848, the tonnage amounted to 436,171, thus showing an increase, in less than ten years, of seventy-fold. But in 1870, the registered tonnage was 1,618,733, or more than three times as much as it was in 1848. And the business of the port is, barring the temporary effects of the periodical fluctuations in trade, progressing in at least an equal ratio. In 1871 the aggregate tonnage was 2,207,713, and in 1872, 2,527,038. To put the increase of the principal items of Cardiff commerce in another light, it may be stated that in 1839 the amount of iron shipped at the port was 1,200 tons, and of coal, 4,562. In 1848 the shipments of iron had advanced to 70,805 tons, and those of coal to 615,111 tons. In 1870, however, the weight of iron loaded at Cardiff amounted to 315,649 tons, and that of coal and patent fuel, which, in the meantime, had become an article of export, to 2,177,518 tons. The amount of coal exported in 1871 was 2,979,843 tons, and in 1872, 3,537,246 tons.

We extract from Messrs. Tellefsen, Holst and Wills' monthly circular a comparative table of shipments during the last year, in all the ports of South Wales.

In	Cardiff.					Swansea. Porthcawl, Port Talb't and Briton Ferry.	Newport.
	Coal.		Iron.	Coke.	Patent Fuel	Coal.	Coal.
	Exports.	Coasting.	Exprts.	Exprts.	Exprts.	Exports.	Exports.
January	210,254	66,829	11,734	1,271	9,115	42,645	19,639
February...	226,577	91,773	6,669	58	7,563	41,302	20,534
March	245,656	96,948	2,265	1,787	9,142	51,339	27,452
April.....	244,483	80,256	6,072	3,857	6,007	59,888	27,494
May	240,321	90,483	15,375	1,838	7,589	61,639	28,653
June	204,875	70,802	19,513	947	4,198	53,414	25,584
July	220,279	81,940	23,268	968	5,032	58,370	26,790
August.....	126,995	50,113	15,604	87	5,354	52,526	22,438
September.	224,927	83,813	18,269	881	3,659	47,041	22,979
October	235,141	88,417	13,483	235	5,200	49,745	31,155
November.	189,654	88,271	13,406	55	3,023	49,889	19,197
December .	257,794	74,617	8,912	292	3,181	47,927	30,377
Total	2,626,956	964,262	154,570	12,276	69,123	615,725	302,292

While examining these docks, there are other considerations that will present themselves. The docks owe all their importance to the minerals on the hills, and the means of transit that have been devised from the hills to the shore. The expenditure on the docks, calculating the further sums necessary for the new works lately resolved on, will be between two and three millions. Speaking roughly, about the same sum has been spent on the railways reaching down to the coast. A capital of some five-and-twenty millions has been expended on the collieries, a capital which, despite the immense gains of the last two years, has hardly yielded five per cent. to the proprietors. In taking count of the Cardiff docks, we ought to have mentioned the excellent little dock at Penarth, virtually provided by the Taff Vale Company. This is situated near the mouth of the river Ely. The river itself is embanked and used as a tidal harbour, with thirteen coal staiths. The dock is approached by a basin and a lock has ten tips. The misfortune is that the present dock is too small to yield a remunerative return. Between Penarth and Cardiff, however, stretch the wide mudflats, which will, in all probability, be converted into the low-water docks of the future.

HYDROGEN IN RELATION TO THE ALKALINE METALS.

EXPERIMENTS upon the reciprocal action of hydrogen and the alkaline metals are now being carried out at Paris by the eminent chemists Troost and Hautefeuille.

The question of the relationship of hydrogen to metals, though unsolved, is by no means new. Gay-Lussac and Thénard observed that if potassium be heated in hydrogen the metal loses its brilliancy, and absorbs a remarkable quantity of the gas, if care be taken to renew the surfaces so as to multiply the points of contact.

In our own country Graham discovered the remarkable property of palladium in the absorption of hydrogen, of which it can take up 982 times its own volume.

The facts, however, established by these inquirers were not generalized by them. They considered the phenomenon sufficiently explained by supposing that the hydrogen was dissolved or condensed. Graham, later, it is true, admitted that palladium formed with hydrogen a mixed metal of even equivalents.

The absorbent property of the alkaline metals being once observed, it began to be utilised in laboratories, and M. Jacquelain proposed by means of it to separate hydrogen from mixtures of this gas with the carburets of hydrogen.

The exact nature of the phenomenon still remained to be determined with precision. The experiments of MM. Troost and Hautefeuille, conducted with a view to this determination,

suffice to establish that hydrogen forms, with potassium, sodium, and palladium, bodies of a strictly definite constitution, the composition of which is respectively represented by the formulas K^2H, Na^2H, Pa^2H.

The principle on which the experiments resulting in this determination have been conducted may be briefly stated as follows :—

Between a body consisting of parts chemically combined and a mass which simply exists by the dissolution or condensation of two elements there is this difference, that the first undergoes, under the influence of heat, a partial decomposition, measured for every temperature by an invariable tension, independent of the quantity of the undecomposed product. This tension is called the tension of dissociation of chemical combination. On the other hand, if water, for example, in which carbonic acid has been dissolved, or spongy platinum which has condensed hydrogen, be taken, and submitted to a temperature more or less elevated, it will be noticed that the gases given off at any point of the experiment have, for the same temperature, tensions which are variable and which are relative to the state of saturation of the body.

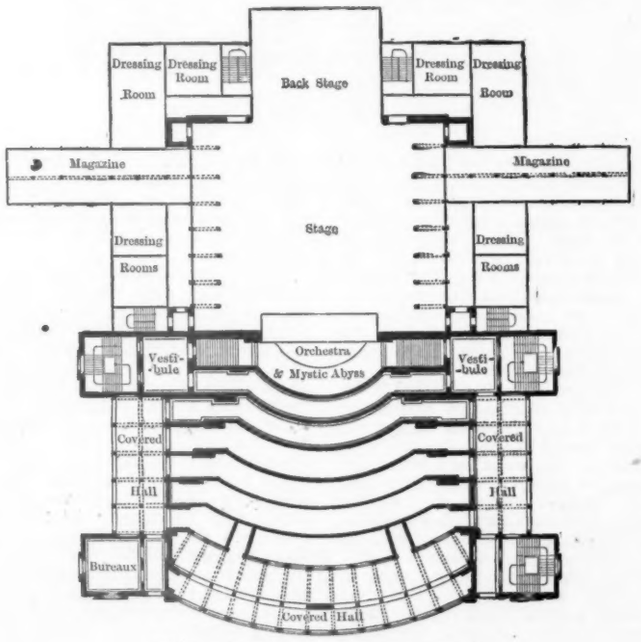
It is on the observation of these tensions that MM. Troost and Hautefeuille have based their experiments. They have submitted potassium, sodium, and palladium, already hydrogenated, to the action of heat, and have found that the hydrogen is given off in such a ratio that the tension of the gas is constant for the same temperature. They have therefore concluded, according to the law above stated, that the bodies they experimented upon were combinations of a fixed and definite character.

The formation of these combinations, which has to be carried out with great care, presents no serious difficulty.

The metal submitted to experiment was contained in an iron cup placed at the bottom of a glass tube. This tube communicated by a T-shaped pipe on the one side with a pressure gauge, and on the other with a three-way tap, which permitted the hydrogen to be brought to the metal in a pure and dry condition. The tube containing the metal could be raised to different temperatures successively. These temperatures were maintained constant for a number of hours sufficient for the observations. The absorption of the hydrogen commenced for the potassium at 200° C., for the sodium at 300° C., and for the palladium at 100° C.

In each case the absorption is slow at these initial temperatures, but increases rapidly with the augmenting heat. If the action of the hydrogen be kept up beyond the point where the definite compounds are formed, the absorption, insignificant in the case of the sodium, is greater with the potassium, and greater still with the palladium.

The hydrogenated sodium, Na^2H, soft like sodium at the ordinary temperature, becomes crystalline and very brittle a little before it reaches the melting point. It has the whiteness of silver, and presents a metallic lustre. The hydrogenated potassium and palladium, prepared in the same manner as the hydrogenated sodium, offer the same characteristics. The most noteworthy of these is that they all exhibit a metallic lustre—the best physical indication of the metallic element which enters into the combination. These bodies therefore seem to claim a right to be considered as metallic compounds; and, so considered, they would establish the theory which regards hydrogen as a true metal.

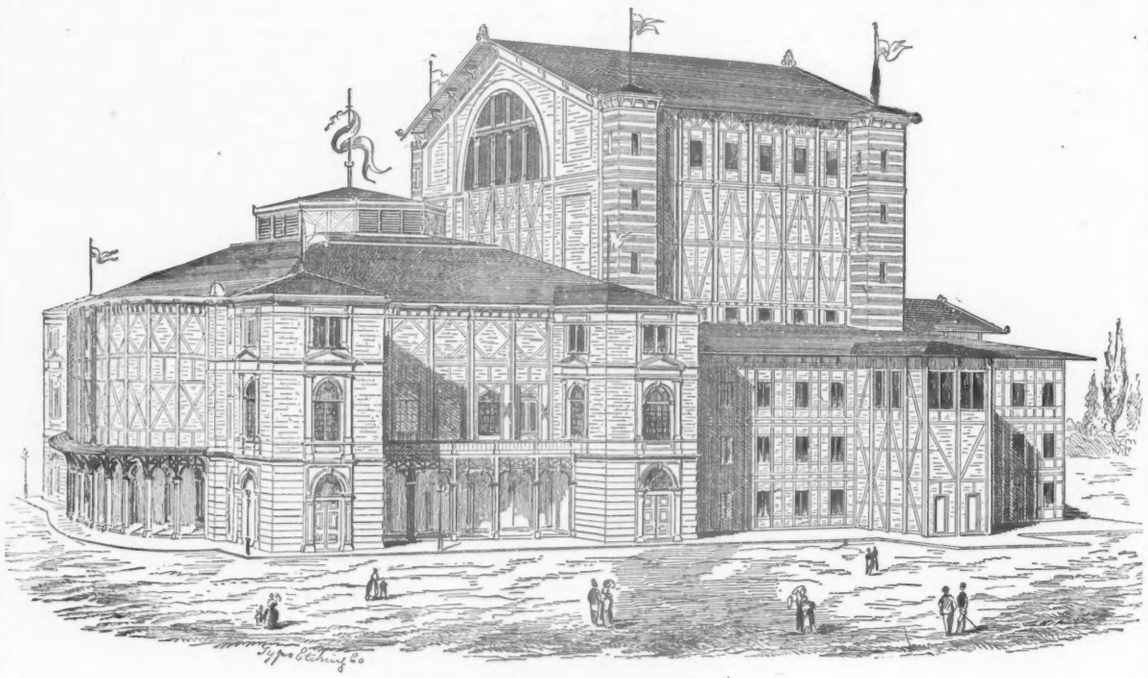


WAGNER'S THEATRE—GROUND PLAN.

HERR WAGNER'S NEW THEATRE AT BAYREUTH.

THE great German musical composer Herr Wagner has formed the idea of founding in Bayreuth, in Bavaria, where he now resides, a dramatic musical school for the promotion of a true national German opera. To enter at large upon Herr Wagner's ideas, grand as they are, upon the subject of the relation of the art, of which he is so skilled a master, to the drama, or to describe fully the scheme by which he proposes to embody them, would be beyond our province. It is sufficient to say that he proposes to illustrate, and to enable the world to comprehend, the true mission of dramatic opera. Herr Wagner's own operas are composed on a strictly dramatic basis, and as a distinctive name he has accepted for them the term music-drama. He finds the modern German theatres unfit for giving the true artistic interpretation to his compositions; and he has planned a building that shall be adapted for his purpose. In it the best operas of the best composers are to be performed in the most perfect possible manner. He has Bayreuth for its site, and for the gathering place of the operatic strength of Germany "in order not to come into contact with a public whose taste is already vitiated." We may add that, besides the form of the theatre, the chief innovations to be inaugurated by Herr Wagner are the natural training of the singers, the introduction of *operatic* system in curbing the license and extravagances of individual "stars," the suppression of the mania for applause among singers, the general working together of the company for the good of the performance, not of the individual, and the fixing of the hour of performance at four o'clock in the afternoon.

Herr Wagner's Theatre was commenced in 1870. It is built on a gentle elevation, called Nibelungen, distant about half a mile from the city. In summer it is a delightful walk thither. The plot of ground on which the theatre stands is about an



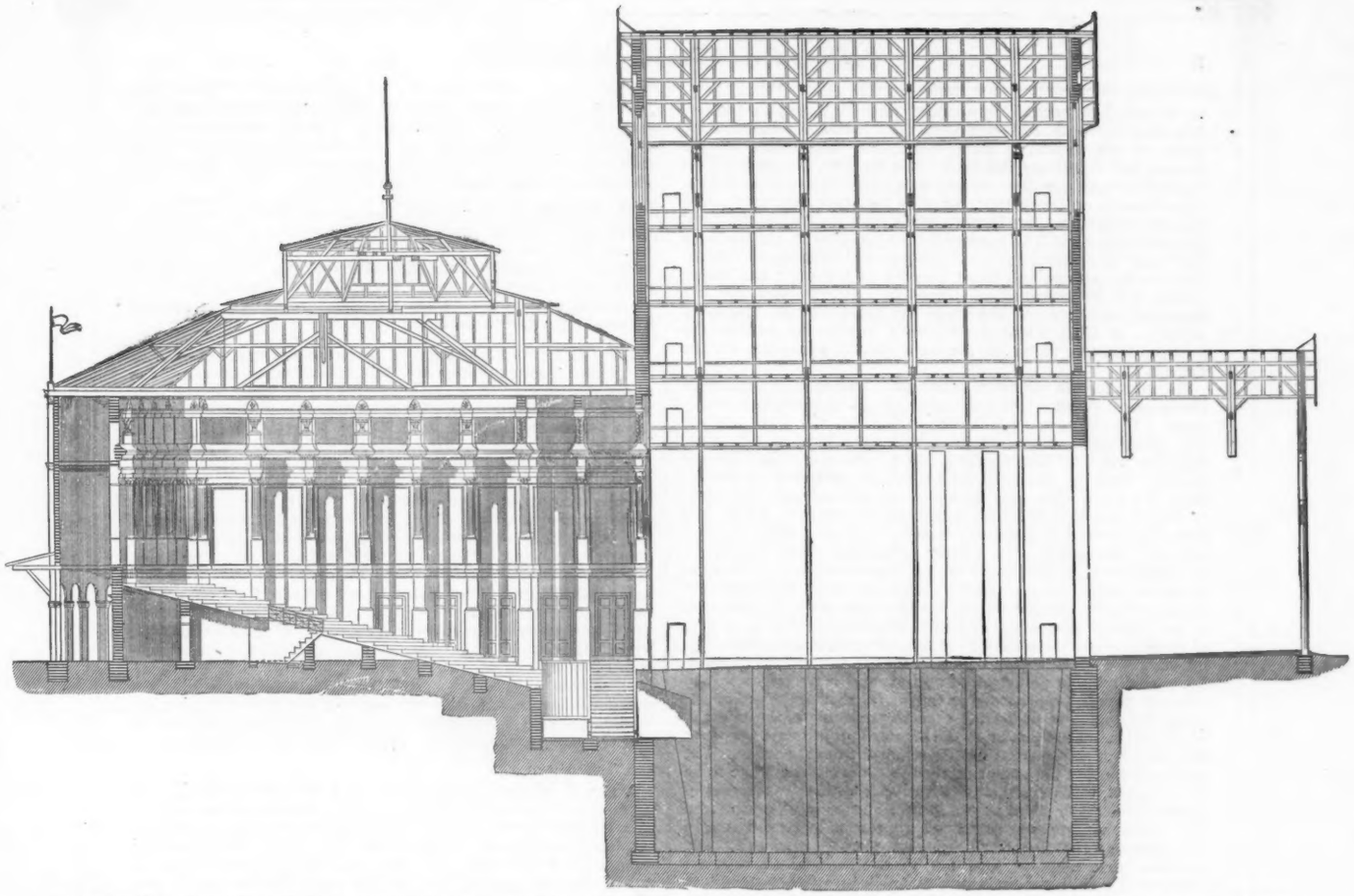
WAGNER'S THEATRE AT BAYREUTH.

acre in extent, and was presented to the composer by the city of Bayreuth. The external structure is now finished. A hundred and fifty workmen were employed on it for eighteen months, and now some fifty or more are busy in furnishing the interior, and in fitting in the woodwork of the stage. The building is of the very simplest construction, the framework is of wood, and the filling-in of brick; only the portion devoted to the stage is built in a solid, durable fashion. Looked at from the outside, the theatre has a style peculiarly its own, having no resemblance to other theatrical structures. The front has a breadth of 170 ft.; the length is 240 ft. The ground plan will give a clearer conception of the form which the structure assumes.

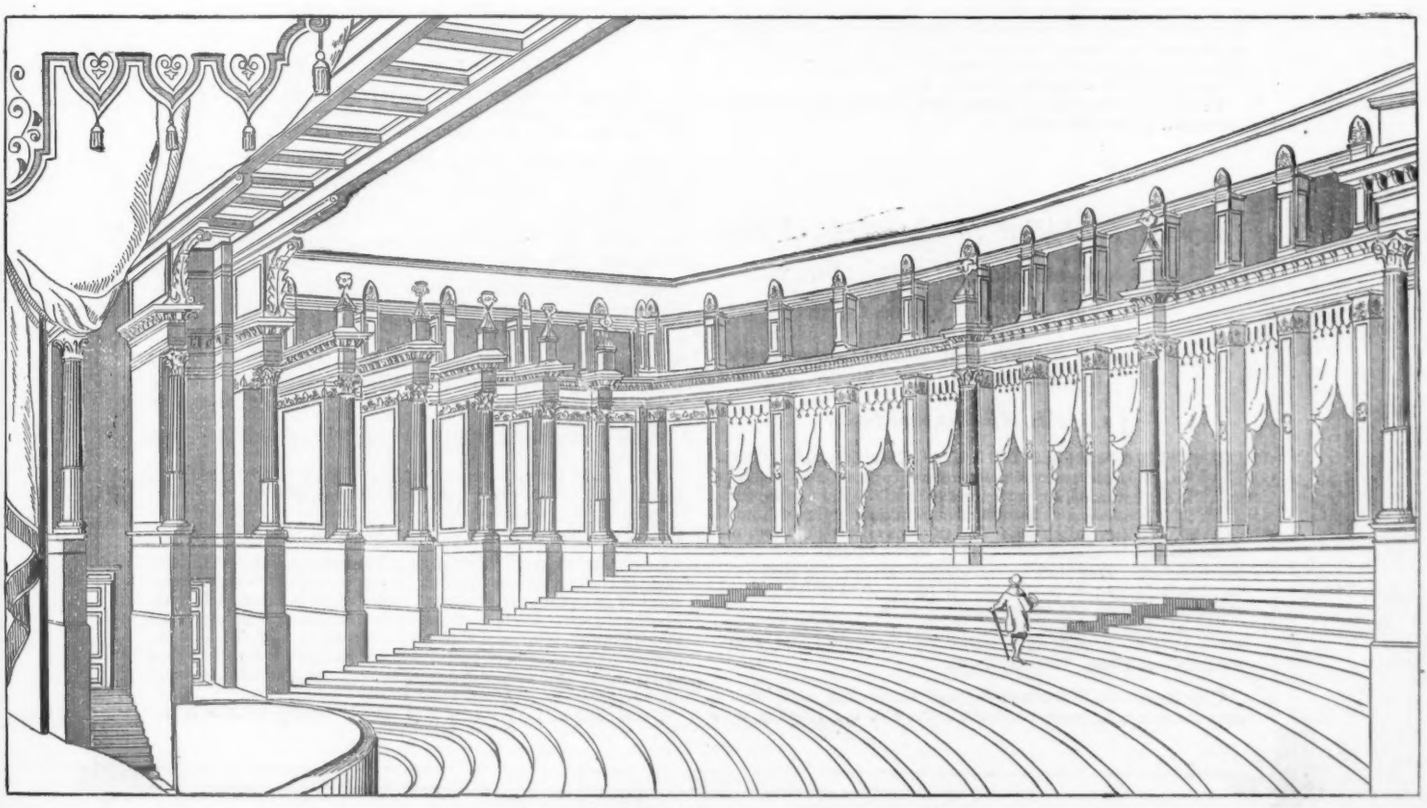
The most remarkable part of the edifice is that devoted to the stage, which is to be the chief point of attraction, and in the decoration and furnishing of which no expense will be spared; while the decoration of the part devoted to the audience will be of the simplest possible character. The stage has a breadth of 95 ft. and a length of 79 ft., and an additional stage behind this is 49 ft. broad and 40 ft. long. It sinks from the stage floor to some 37 ft., and its entire height from the floor of the excavation up to the "pulley-floor" is 176 ft. But these figures give no adequate idea of the grand scale on which the stage is constructed. Looking up from the parquet, the 5-inch baulks of the pulley floor diminish to half their actual size. The great depth below the stage is necessary, especially in the "Rheingold" scenery, which must descend as well as ascend. On either side of the stage are two ranges of dressing-rooms for the singers, which will be comfortably furnished. At each of the four corners of the stage proper a massive water-tower is built. There are no arrangements for heating the theatre, since the performances will take place in the summer months.

The portion set apart for the audience is in breadth 114 ft., and in length, from the royal circle to the proscenium, 79 ft. The seats rise step by step from the orchestral space up to the circle "amphitheatrically," as seen in our plan, growing in length the further back they are removed from the stage. There are no side galleries; the royal "circle" is a few feet higher than the last row of seats; above there will be a gallery for the accommodation of five hundred of the citizens of Bayreuth, who will be invited by Herr Wagner to attend the performances. The amphitheatre will accommodate fifteen hundred persons. The entrance to the ten or twelve front rows of seats will be through four doorways at either side; the back rows will be approached from the front of the edifice, from the vestibule, by two passage ways running beneath the last six or seven rows of seats, and emerging about a third of the way down the amphitheatre. The garderobes for the amphitheatre extend the whole width of the theatre immediately beneath the royal circle or gallery. There being no pillars to obstruct the sight, the view of the stage and the perspective will be perfect from every seat of the house. The proscenium itself is 45 ft. wide, and is, we believe, the widest in Germany.

Between the stage and the audience there is an excavated space in which Wagner will place his orchestra, which will consist of a hundred and six instruments. (The largest orchestra in Germany is, we believe, that of Munich, and numbers seventy-six members.) It lies 17 ft. below the first row of seats, has a depth of about 28 ft. (10 of which extend under the stage), and takes in the whole width of the stage. This space has been styled by Wagner the "Mystic Abyss." The seats for the musicians are raised one above the other, the conductor occupying the highest position, so that, though his wand will not be seen by the audience, he will have full command of the singers on the stage. There will be no footlights. "And where are you going to place the prompter's box?" "That," answered our informant, "will be dispensed with altogether. Herr Wagner will have the singers perfect in their rôles before the performances commence. Herr Wagner intends that between the audience and the singers and scenery nothing shall intervene to interrupt the view or attract the attention,—nothing but this invisible wall of music." Herein consists a chief characteristic of the Wagner theatre. The impression one gets of the theatre in its present unfinished condition is that it will be a very comfortable, cozy place. The roof looks very low to the eye accustomed to theatres with four or five tiers of boxes. Adjoining the royal gallery are several drawing rooms, and at either side of the theatre, on a level with the royal circle, a balcony for the use of princely and royal people. Immediately underneath these again are arcades which may be used by the audience proper for promenading. The portico front will be used for the same purpose. There will be two restaurant rooms in the side wings. About 100 ft. to the rear of the theatre is a temporary structure for the use of the scenic artists; which during the season of performance will afford lodging accommodation for musicians and persons connected with the theatre. Between the painters' room and the theatre will be a petroleum gas manufactory, a gasometer, and an engine house. In the course of time the space about the theatre will be tastefully laid out, and an avenue of trees will lead out from the central part of the town to the Nibelungen mount. When the theatre is completed and the grounds laid out, and the fountains in full play, and the people assemble from all parts of the world to the musical festivals of



WAGNER'S THEATRE—SECTION, SHOWING THE AUDITORIUM, THE OPEN SPACE FOR THE ORCHESTRA, AND THE FRONT AND BACK STAGES.



WAGNER'S THEATRE—THE AUDITORIUM.

the future, then there will be no more charming gathering-place in Germany for music-loving people. The architect who made the plans for the theatre is Herr Bruckwald, the builder of the Leipsic and Altenburg theatres. The resident architect is Carl Runkwitz, who, we believe, has a brilliant future before him. Herr Brandt, of Darmstadt, supplies the stage machinery, and him, we understand, we have to thank for the delay in the completion of the work. The scenery is being painted by the Brothers Brückner in Coburg, from the designs of Hoffmann, of Vienna. The smaller scenes are being painted in Coburg; the larger pieces will be executed in Bayreuth. Every plan for the theatrical structure, for the stage machinery, every design for scenery, is from Richard Wagner's brain,—he knows the meaning of every stone in the structure, of every line on the canvas.

So much for the theatrical structure. The invisible orchestra is the most important divergence from the customary arrangement. On this point Wagner remarks: "I have named this great space, extending from below the level of the stage, and the width of the *parterre*, up to the roof, the 'Mystic Abyss;' because, as I tell my friends, it separates the reality from the ideal. My idea in rendering the orchestra invisible is to prevent the technical apparatus of musical production attracting attention from the stage. Between the audience and the perception of a picture presented there should be no interruption, there should be no intervening reality between the audience and the ideality if we would produce perfect illusion. But, as you see, the innovation made a change in the structure of the theatre necessary; we had to exclude the system of tiers of boxes and confine ourselves to the amphitheatrical formation, by which we afford accommodation for fifteen hundred persons. I banish footlights and prompter's box, and leave only a framework, as it were, for the stage pictures. In front of the orchestral space the architect devised a second proscenium, the effect of which will be, in its relation to the proscenium proper, to produce the illusion of an apparent further removal from the scene. The effect will be that the audience, though fancying the scene to be far removed, will nevertheless perceive it with the clearness of immediate vicinity; and then a further illusion will be produced that the persons on the scene will appear in increased size, in superhuman form. But of all this I have written much. I think, however, that most persons fail to comprehend the distinct character I give to the orchestra, as an illustrative organism, to occupy the place of the ancient Greek chorus—a high invisible language appealing constantly to the audience, revealing, recalling, expounding." It needs deep and careful studies of Wagner's operas to become acquainted with the nature and beauty of his music, and especially its relation to the Greek chorus. The duty of the Greek chorus was, in connection with the choragus, to mediate, as it were, between the audience and the actor, to explain, to elucidate, and to chant the teachings of the play. Wagner gives his orchestra a similar duty.

The performances in the Nibelungen Theatre are intended to commence in the year 1876.

Chemistry applied to the Arts, Metallurgy, Chemical Manufactures, and Allied Subjects.

ABSTRACTS FROM FOREIGN PERIODICALS, TRANSACTIONS OF CHEMICAL SOCIETIES, &c.

§ 1. *Acids, Alkalies, and Salts.*

Manufacture of Citric Acid. CHARDON patents the following process:—The limes, citrons, &c. are expressed and the juice fermented; chalk is then added and finally milk of lime to neutralization. The calcium citrate thus obtained is washed with boiling water, drained and dried; the citric acid may then be extracted either on the spot or in suitable factories; it can be readily transported without inconvenience. Baryta can be used instead of lime.

The alcohol produced during the fermentation can be easily collected without materially increasing the working expenses. *Bulletin Soc. Chim. Paris, xxi.* 534.

Citrates.—H. KAEMMERER has investigated many of the salts of citric acid, more particularly those of the alkali metals (double citrates of potassium and sodium cannot be formed) and the citrates of barium, strontium, calcium, magnesium, zinc, cadmium, iron, copper, and lead; *iso-citric* acid, said to be obtainable by the action of sodium amalgam on citric acid, does not exist. *Annalen der Chem. und Pharm. clxx.* 176.

Purifying Raw Acetic Acid.—STEEDMAN proposes to purify acetic acid by conducting the vapours of the same as it comes from the stills through molten paraffin, which is said to possess the property of retaining all impurities and allowing the acetic acid vapours to leave. *Polytechnisches Centralblatt.*

[*Note by Abstractor.*—Does not the paraffin impart some of its own impurities to the acid? R. G.]

Impurities in Commercial Sulphuric Acid.—C. R. A. WRIGHT states that one of the disadvantages attending the use of pyrites instead of sulphur in the manufacture of sulphuric acid is the much greater degree of impurity of the acid made from pyrites owing to the volatilization and mechanical carriage of various substances from the pyrites burner to the vitriol chamber. Of these substances arsenic is by far the most objectionable, whilst iron, zinc, thallium, selenium, &c., are frequently introduced into the vitriol. For many practical purposes these impurities are not of any consequence, but the impregnation of sulphuric acid with arsenic produces as an end result the contamination of a large number of chemical products with that deleterious substance. Saltcake, hydrochloric acid, soda ash and crystals, soap, and many other products requiring the manufacture of sulphuric acid as a step to their production, frequently contain traces and even more of arsenic derived from this source; and the widespread presence in many substances of household use, and even articles of food and medicine, of this objectionable ingredient, is in all probability not without influence on the general health of the population, besides lending additional complications in the detection of arsenic in toxicological investigations. *Paper read before the Society of Arts.*

Vitriol Manufacture.—C. R. A. WRIGHT states that to produce a given amount of vitriol more chamber space must be allowed when pyrites is used as material than is required if pure sulphur be employed; in the latter case the resulting sulphur dioxide is diluted only with that amount of nitrogen (leaving out of consideration unchanged air) associated originally with the oxygen of the sulphur dioxide; but when pyrites is burnt, the resulting sulphur dioxide is diluted not only with this amount of nitrogen, but also that originally associated with the oxygen taken up by the iron of the pyrites. The reactions by which the sulphur dioxide is formed are respectively indicated by the equations—

$$4\,S_2 + 8\,O_2 = 8\,S\,O_2$$
$$4\,Fe\,S_2 + 11\,O_2 = 8\,S\,O_2 + 2\,Fe_2\,O_3$$

i. e. the quantities of air requisite for burning sulphur and pyrites respectively, so as to produce the same amount of sulphur dioxide in each case, are in the proportion of 8 to 11. *Ibid.*

New Source of Sulphur.—A large hill, consisting almost of pure sulphur, was discovered about two years since, 900 miles west of Omaha, and 30 miles south of the Union Pacific railroad. It is said to be almost pure sulphur, containing only fifteen per cent. of impurities. *Journal of the Society of Arts, May 15th,* 1874.

Manufacture of Alkalies.—HARGREAVES and ROBINSON propose the following modification in Leblanc's process:—

In addition to the coal, they also mix iron oxide with the alkaline sulphates, and this mixture is fused in crucibles which have an outlet at the bottom to allow the fused crude soda or potash to flow out when finished. The proportions of coal and oxide are somewhat in excess of what would be chemically equivalent to the sulphates.

Other oxides besides that of iron may be employed with equal advantage.

The resulting iron, manganese, &c. sulphides are treated with hydrochloric acid, when sulphuretted hydrogen is produced; or they are first oxidized by being exposed to the air, and then treated with hydrochloric acid, in which case sulphur is set free.

Composition of Bleaching Powder.—SCHORLEMMER finds that the results arrived at by Goepner ("Practical Magazine," Feb., 1874) are incorrect; bleaching powder yields, on distillation with dilute nitric acid, a distillate containing much hypochlorous acid, and the same product can be obtained by distilling the product of the action of chlorine on finely divided carbonate of lime suspended in water. *Journal of the Chemical Society, from Berichte der Deut. Chem. Ges. vi.* 1509.

RICHTERS and JUNCKER find that bleaching powder is de-

composed by carbonic acid, with the production of hypochlorous acid and chlorine, provided that an excess of water be present; normal dry bleaching powder, however (expressed by the formula $2\ CaO\ Cl_2, CaO, 3\ H_2O$ — Kolb) is not affected by carbonic acid. On distillation of normal bleaching powder with dilute phosphoric acid, chlorine is evolved, but no hypochlorous acid, wherefore hypochlorite of calcium cannot be present in bleaching powder, that salt not being decomposed by phosphoric acid.

From the results of their experiments the authors conclude that bleaching powder is decomposed by water into chloride and hypochlorite of calcium, but that these salts do not exist as such in the powder. *Bull. Soc. Chim. Paris, xxi.* 328, *from Dingler's Pol. Journal, ccxi.* 31.

Fig. 1.

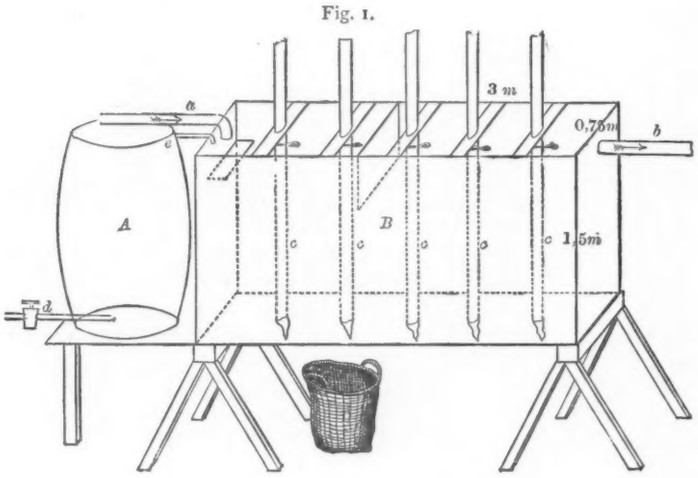
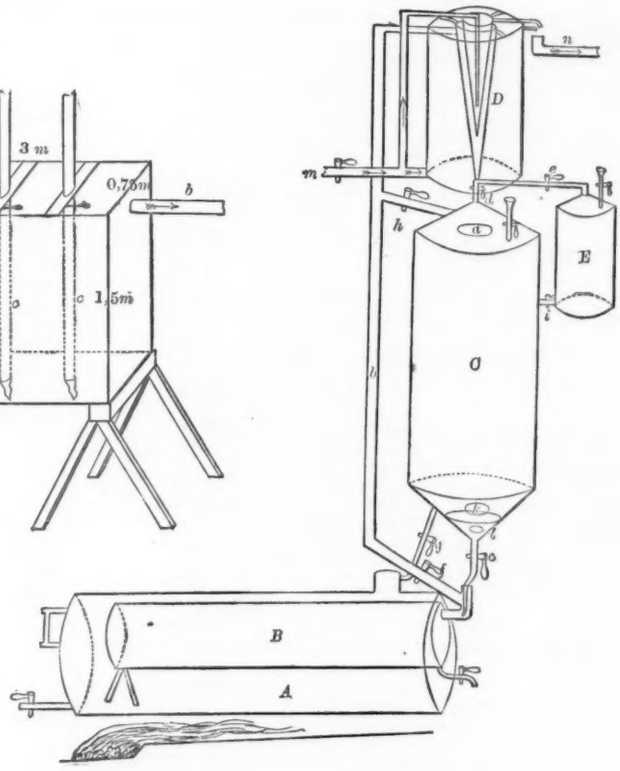


Fig. 2.



Utilization of Waste Soap-liquors.—HEUZE proposes the following apparatus for the collection of the liquors (fig. 1.) The tub A is half filled with slaked lime, and through it, as well as through the tubes *d* and *e*, a stream of water is permitted to flow, which brings lime into B, where at the same time the soap liquors enter which pass away at *b*. As soon as a certain amount of mud has settled on the bottom of B, the stopper *c* is pulled out, and the mud allowed to run, with continued admixture of lime water, into the filter baskets D. The lime soap thus obtained is decomposed by some mineral acid (hydrochloric or sulphuric) and steam, and the liberated fatty mass, after washing, is freed from its impurities (sand, particles of wood, &c.) through treatment with bisulphide of carbon. A convenient apparatus for this purpose is represented in fig. 2. The still B, intended for the reception of the fat, is placed in another one, A, filled with hot water. The impure fat is put into C; D is the cooling vessel, and E the reservoir containing the bisulphide of carbon. After charging cylinder C, which rests on a perforated bottom between the outlets K and *l*, with fat mud, some bisulphide is passed into it from E through *i*, which, after taking up the fat, runs through *e* into the still B. Here the bisulphide evaporates, passes through *b* into D, condenses there, flows again into C, and thence, newly charged with fat, into B. After the mud has in this manner been deprived of all fat, the taps *e*, *f*, *g* and *h* are opened, and simultaneously those at *c*, *d* and *i* closed. The effect of this operation is, that steam enters through *g* into C, and expels from here through *h* the bisulphide of carbon, which collects, together with that condensing in B, in E; *k* and *l* are openings for the evacuation of C.

An apparatus of this construction allows the almost complete extraction of the fat, and, at the same time, reduces the loss of bisulphide of carbon to the merest trace, provided the cooling vessel D is supplied through *m* with the necessary quantity of water. *Dingler's Polyt. Journal, ccvii.* 463.

Deacon's Chlorine Process.—R. HASENCLEVER reproduces the following results:—

(1) Influence of increase of temperature, the quantity of acid in the mixture of air and hydrochloric acid, and the velocity of the gaseous current being approximately constant.

Percentage of hydrochloric acid in gaseous mixture.	Velocity in meters per second.	Temperature centigrade.	Percentage of hydrochloric acid decomposed.
35·7	0·0087	378	1·5
32·5	0·0090	378	3·6
35·4	0·0104	457	28·1
36·9	0·0087	498	66·2
38·6	0·0095	511	66·1
40·6	0·0093	553	61·2

(2) Influence of gaseous composition, the temperature and velocity remaining nearly constant.

Hydrochloric acid in mixture.	Velocity.	Temperature.	Hydrochloric acid decomposed.
41·9	0·0067	438	26·2
30·0	0·0063	438	40·3
22·0	0·0061	438	60·5
21·5	0·0060	438	62·0
18·9	0·0065	438	69·1
15·7	0·0062	438	83·8

(3) Influence of velocity of gaseous current, the temperature and composition remaining approximately constant.

Hydrochloric acid in mixture.	Velocity.	Rates of Velocities.	Temperature.	Hydrochloric acid decomposed.
37·2	0·00073	1	438	42·9
36·0	0·00127	1·74	440·5	43·4
38·8	0·00265	3·63	406·6	28·4
40·4	0·0061	8·38	432	15·2
39·0	0·0093	13·2	438	16·0
40·2	0·038	53·4	438	7·2

Bulletin Soc. Chim. Paris, xxi. 369, *from Berichte der Deut. Chem. Ges. vii.* 2.

Soap.—W. LORBERG asserts that the following two mixtures yield superior soaps :—

(1) Pale yellow palm-oil soap,

Tallow	50 lbs.
Cocoa nut oil	46 „
Palm oil	4 „
Alkali, 40° B.	50 „
Alkali silicate, 40° B.	30 „
Gluten	30 „
Water	30 „
Soap	240 „

(2) Rosin soap,

Tallow	45 lbs.
Cocoa-nut oil	45 „
Rosin oil	10 „
Alkali	56 „
Alkali silicate	50 „
Gluten	30 „
Water	30 „
Soap	266 „

The mixing of all ingredients takes place in the cold, the tallow being heated only to melting.

A. FRICKE states that soap is decomposed by excess of water into free alkali and an insoluble acid salt of the fatty acids present : thus, a sample of soap containing—

Fatty acids	84·48
Soda	9·86
Water	5·66
	100·00

yielded an insoluble and a soluble portion containing respectively—

	Insoluble part.	Soluble part.
Fatty acids	86·78	53·28
Soda	8·21	8·31
Water	5·01	38·41

i. e. the latter containing more than half as much alkali again in reference to the fatty acids as the former. The fatty acids of the more soluble portion appear chiefly to consist of oleic acid, those of the less soluble part of palmitic acid.—*Journal of the Chem. Soc. from Dingler's Pol. Journal, ccix.* 46.

Estremadura Phosphorite (Superphosphate).—B. NIEDERSTADT finds that this superphosphate (imported from Spain) contains but little iron and alumina ; hence it is not so apt to "go back," *i. e.* to suffer the decomposition of the soluble phosphate with the simultaneous formation of insoluble phosphate. The author gives the following average analysis :—

Water	0·25	0·18	0·80	0·73
Silica	25·72	16·41	29·43	19·16
Tricalcic phosphate	54·69	62·35	57·37	59·60
Trimagnetic phosphate	7·01	1·61	0·71	3·98
Calcium carbonate	8·06	13·69	7·39	13·33
Calcium sulphate	1·20	2·44	1·60	0·86
Ferric oxide	0·63	0·53	0·46	0·92
Alumina	0·17	0·99	0·41	0·43
Calcium fluoride	1·53	1·20	1·83	0·99
	99·26	99·40	100·00	100·00

Journal of the Chem. Soc. from Berichte der Deut. Chem. Gesellschaft, vii. 107.

Phosphate of Ammonia.—LAMY states that this salt is extensively used for the purpose of neutralizing the alkalinity of saccharine pieces ; it is prepared by dissolving rich mineral phosphates in dilute sulphuric acid (at 5° B.) ; after clarification by standing the excess of sulphuric acid is removed by carbonate of barium ; the liquor is then concentrated to 20° B., and neutralized by ammonia ; sulphate of calcium, iron oxide, and other insoluble matters are deposited, and the liquor is then treated with a fresh quantity of ammonia, whereby a comparatively sparingly soluble tribasic ammonium phosphate is thrown down ; this is drained and barrelled immediately. The insoluble deposits thus obtained constitute a good manure, easily assimilated by vegetation. *Bulletin Soc. d'Encouragement,* 1874.

§ 2. *Metallurgy.*

Connection between the specific gravity of Bessemer Steel and the amount of Carbon present therein.—KOPPMAYER finds the following values for different samples of steel made from the same pig-iron :

Percentage of Carbon.	Specific gravity at 13° C.
0·14	7·9219
0·19	7·8784
0·30	7·8754
0·46	7·8711
0·55	7·8632
0·57	7·8569
0·66	7·8530
0·80	7·8434
0·87	7·8378
0·96	7·8291

Hence the specific gravity becomes regularly less as the percentage of carbon increases. *Bull. Soc. Chim. Paris, xxi.* 331, *from Dingler's Polytech. Journal, ccxi.* 22.

Tempering and Refining Steel.—W. N. SEVERANCE proceeds in the following manner : The steel is heated to a cherry red in a clear smith fire, then covered with common salt, and worked in this condition until it is brought nearly into its finished form, when it is sprinkled with a mixture of the following substances :—

Copper sulphate	3 lbs.	2 oz.
Sal soda	4 „	10 „
Sal ammoniac	6 „	
Alum	2 „	6 „
Potash nitrate	1 „	8 „
Rock salt	6 „	4 „

The mixture is to be kept in tightly closed stone or glass vessels. After alternately heating the steel and covering it with the mixture, the tempering operation is finished by dipping the articles in the following bath :—

Copper sulphate	2 lb.	6 oz.
Sal soda	2 „	
Sal ammoniac	2 „	
Alum	2 „	6 „
Potash nitrate		12 „
Rock salt	9 „	6 „

Water to make up to 25 gallons.

Importations of Pyrites into Great Britain.—H. DEACON gives the following numbers, compiled from the returns of the Board of Trade, the figures for 1873 being not yet published.

	Norway. *Tons.*	Holland. *Tons.*	Belgium. *Tons.*	Portugal. *Tons.*
1862	4,975	6,817	9,860	53,296
1863	6,736	15,409	12,059	109,180
1864	16,087	12,751	7,069	118,489
1865	22,229	14,727	2,121	137,787
1866	38,262	21,574	4,006	165,993
1867	77,895	34,592	2,299	105,556
1868	63,007	41,559		75,883
1869	63,091	13,983		140,805
1870	67,467	14,914		174,459
1871	74,416	12,809		*120,573
1872	71,665	5,682		180,329

	Spain. *Tons.*	Italy.	Other parts. *Tons.*	Total. *Tons.*
1862	33,717		2,187	110,852
1863	33,213		2,628	179,225
1864	15,529		1,065	170,990
1865	16,393		369	193,626
		Sardinia.		
1866	11,910	1,226	1,625	244,596
1867	50,222		2,134	272,698
		Sicily.		
1868	47,458	794	1,019	229,720
1869	99,648		2,420	319,947
1870	150,996		3,676	411,512
1871	242,163		4,581	454,542
1872	257,429		2,521	517,626

Journal of the Society of Arts, June 5th, 1874.

* And Azores.

Copper Alloys.—A. RICHE finds that alloys of tin and copper are subject to eliquation when the composition is different from that indicated by the formulæ $SnCu_3$, and $SnCu_4$, being the more marked the higher the percentage of tin. The alloy $SnCu_3$ is different in colour from other tin-copper alloys, and can be pulverized; the maximum contraction occurs during the production of this body, which must be regarded as a definite compound like the silver-copper alloy Ag_3Cu_1.

Bronzes rich in tin (18—22 per cent.) increase in specific gravity on hardening, and diminish on annealing; these results are the reverse of those noticed with steel, agreeably with the fact that steel is hardened, and bronze softened by rapid cooling; this softening, however, is not sufficient to enable the bronze to be hammered cold; although very hard when cold and pulverizable at a red heat, bronze can be forged and laminated at a dull red heat, so that tam-tams, gongs, &c. can be thus prepared. With bronzes poor in tin (6—12 per cent.) this softening is scarcely perceptible.

In a bronze cannon, portions were found specially rich in zinc and tin, the axis being less rich in tin than the periphery; the specific gravity did not increase from the mouth to the breech.

Bronzes containing 3—4 per cent. of tin can be readily employed in the manufacture of medals; the presence of traces of iron in copper does not impair its ductility, but confers upon it considerable tenacity; thus laminated copper offered a resistance of 28 kilogs. per square millimeter, whilst ferriferous copper laminated in just the same way had a resistance of 40 kilogs.; the hardness is similarly increased.

Copper subjected to alternate mechanical action, and annealing or hardening, experiences inverse variations, according as this is done in air or out of contact with air; in the first case the mechanical action increases the density, in the second it diminishes it. Copper not naturally porous becomes so on heating in charcoal powder; so much so as to become permeable to liquids; a high temperature, energetic lamination, formation of oxide on the surface by heating in air, or presence of small quantities of iron removes this permeability.

Alloys of copper of zinc indicated by the formulæ Zn_3Cu_3 and Zn_2Cu, are brittle like the copper-tin alloys $SnCu_3$ and $SnCu_4$; they possess no single useful property; the maximum contraction occurs in their production.

Mechanical action increases the specific gravity of brass, this effect being partly corrected by hardening, and especially by annealing; on the other hand, neither hardening, annealing, nor mechanical action produces any sensible action on "similor" and aluminium bronze, alloys remarkable for the ease with which they can be worked.

Grey cast iron heated in charcoal dust or even in an empty chest surrounded by charcoal becomes permeable to liquids; also if heated in an empty crucible in a muffle after removing the outside layer of oxide by means of a file. Under these last circumstances, copper does not become porous.

Hardening increases the density of brass and bronzes rich in tin and previously annealed, the contrary result being produced with steel copper and glass. *Annales de Chimie et de Physique*, [4] *xxx.* 351.

Gold Mining in New South Wales.—The gold-mining industry of New South Wales shows a considerable falling off in the returns for 1873 as compared with those of 1872. The Western district gave 268,418 oz., against 307,266 oz. for 1872; the Southern 50,692 oz., against 74,807 oz.; and the Northern 9,086 oz., against 14,271 oz. *Journal of the Society of Arts, May 15th*, 1874.

§ 3. *Dyeing, Calico Printing, Bleaching, Tanning, and allied subjects.*

Growth of Madder in England.—T. SIDEBOTHAM publishes the results of some experiments on the cultivation of madder-roots, made some years ago in England. A piece of rich land in Derbyshire was sown with seed from fine palud madder, early in the spring of 1868; in the autumn the madder plant came into flower and the roots of some pulled up measured 13 in. The plants came up in the spring of 1869 very strong and healthy, and so on until August, 1871, when they were dug up. To produce the best results, the roots should have remained another year in the ground, but for experimental purposes this growth was considered sufficient. The quantity produced was small, in appearance and size the roots were about equal to fine French roots, but on breaking them, instead of the deep red colour in the best French roots, they were orange or yellow.

The dyeing properties were of a very disappointing character; the colours after soaping were loose and similar to Dutch madder, pinks and reds being loose and weak, and the purple element entirely wanting; probably the cause of this is deficiency of sun and heat in this climate.

Madder Colours.—F. VERSMANN gives the following table, illustrating the different properties of the principal colouring matters contained in madder.

Name.	Spectroscope.	Crystallization.	Effect of heat.	Alkalies.	Benzole.	Alcohol.
Alizarine. .	Band near red.	Long orange-coloured needles.	Readily sublimes.	Blueish purple solution.	Soluble.	Soluble, more readily in warm than cold.
Purpurine .	One band near red, another near yellow.	Red needles, sublimed and then crystallized from alcohol.	Sublimes with decomposition.	Red solution.	Soluble.	Same as above.
Pseudo-purpurine .	Same as above.	Fine brick red needles crystallized from benzole.		Red solution.	Soluble.	Very little soluble.
Orange matter . . .	No bands.	Small groups crystallized from alcohol.	Decomposes and yields purpurine.	Red solution.	Insoluble.	Readily soluble.
Purpurosanthine . .	No bands.	Yellow needles. crystallized from alcohol and benzole.	Sublimes.	Yellow solution.	Soluble.	Soluble.

"*Alizarin*," *by F. Versmann, New York.*

Removing Stains from Clothing.—The following hints for the treatment of various kinds of stains may prove acceptable to many of our readers:—

Nature of stains.	*On white goods.*	*On coloured cotton goods.*	*On coloured woollen goods.*	*On silk goods.*
Mechanically attached particles.	Beating, brushing, and allowing water to fall from an elevation upon the wrong side of the goods.			
Mucilage, mucus, sugar, jelly.	Washing out with tepid water.			
Fats	Washing out with soap or lye.	Washing out with tepid soap and water.	Washing out with tepid water and soap, or spirits of hartshorn.	Benzine, ether, spirits of hartshorn, magnesia, chalk, clay, yolk of eggs.
Oil colours, varnish, resin . .	Oil of turpentine, alcohol, benzine, and then soap.			Benzine, ether, and soap, very carefully, and in a very weak solution.
Stearine . . .	Strong pure alcohol.			
Vegetable colours, red wine, fruits, red ink .	Sulphurous vapour, or hot chlorine water.	Washing out with lukewarm water and soap, or spirits of hartshorn.		As with the preceding articles, but very cautiously.
Alizarine inks .	Tartaric acid, the older the spot the more concentrated.	If the colour permits, dilute tartaric acid.		As before, but with great precaution.
Blood and albuminous spots .	Simply washing out with tepid water.			
Rust, and spots of ink made of nut-galls . . .	Hot oxalic acid, dilute hydrochloric acid, and then tin filings.	In genuine coloured goods, citric acid to be tried.	Citric acid to be tried; or, in non-coloured woollen goods, dilute hydrochloric acid.	Nothing can be done without increasing the evil.
Lime, lye, and alkalies in general	Simply washing.	Much diluted citric acid, drop by drop, upon the moistened spot, to be spread around by the finger.		
Tannin substances, fruit, or green nutshells, leather . . .	Bleaching lye, hot chlorine water, concentr. tartaric acid.	Chlorine water, diluted according to the delicacy and colour of the material, applied with a rag, and drop by drop on the spot moistened, alternately applied and then rinsed off.		
Acids, vinegar, sour wine, must, acid fruits, &c. .	Simply washing; in the case of fruit, also with hot chlorine water.	According to the delicacy of the material and the colour, more or less diluted spirits of hartshorn, to be spread around on the spot, moistened, drop by drop, with the tip of the finger.		
Tar, waggon grease, as also fat, resin, carbonaceous particles, and wood vinegar . . .	Soap, with oil of turpentine, varied with the action of falling water.	Hog's lard to be rubbed on, then soaped and allowed to remain quietly, then washed alternately with water and oil of turpentine.		As in the preceding, but more carefully, and instead of turpentine, benzine and current of water falling from a height upon the wrong side of the spot.
Superficial loss of substance by scorching. . .	Rub over thoroughly with a pad dipped in hot chlorine water.	Whenever possible, colouring over, or raising up the nap.		Nothing can be done.

Rigter's Manual of Domest. Econ.

Alizarine Derivatives.—W. H. PERKIN finds that by the action of bromine on alizarine, a brominated product (*monobromalizarine*) is formed; as a dyeing agent this retains all the powers of combining with mordants possessed by alizarine, and the colours appear to be equally fast; slightly different shades are however produced with this new dye stuff; the reds are less purple and the purple less blue than those produced with alizarine. Like alizarine, this brominated product yields a diacetyl-derivative on treatment with acetic anhydride. *Journal of the Chem. Soc.* [2] *xii.* 401.

Artificial Alizarine.—VERSMANN states that the artificial product is mostly sold as paste, which is better applicable than a dry powder, which would not mix so well and uniformly. Of course this paste is not chemically pure; but whereas two years ago many samples did not contain more than 5 per cent. of alizarine, the quality has now vastly improved.

Pure alizarine may readily be obtained by evaporating the paste, and then extracting the colouring matter, or by sublimation.

Great doubts were first expressed as to the quality of the dye compared with that of madder preparations, but they seem not to exist any longer; it has been convincingly proved by Bolley, Kopp, Schunck, Perkin, and others, that the natural and artificial alizarine are identically the same, and the same results are produced with each.

The question of price has also been settled, whereas not two years ago the difference was greatly in favour of madder; it is now about the same, in consequence of the greatly increased production.

There is now one factory in this country, founded by Perkin, one in France, and more than a dozen in Germany and Switzerland. Some idea of the extent of this manufacture may be formed, from the fact that last year more than 1,000 tons of 10 per. cent. paste were produced, in value of £500,000, and it is stated that one German firm are preparing to make 500 tons a-year.

The effect upon madder cultivation has naturally been most serious; and especially at Avignon, the question is most anxiously discussed whether the artificial alizarine will ultimately drive the madder out of the market altogether. The vitality of the new product is more than secured; but although it must very seriously injure the madder interest, it need not necessarily kill the natural product altogether. There may be room for both, and an increased production may, and undoubtedly will, insure a vastly increased consumption.

No doubt the madder growers will have to struggle hard in the competition, and of this they seem to be aware already. Only the other day the Agricultural Society at Avignon inquired of the Industrial Society at Mulhausen what they had to fear from artificial alizarine. The answer was, that to compete successfully, they must improve their product; they must not only sell the raw material, containing but a few per cent. of valuable matter, but they must call in the assistance of science; they must manufacture the extracts of such quality as is made in Paris and England; but that it was impossible to drive the artificial product out of the market again. In this manner, the artificial alizarine will have the merit of improving the quality of its ancient rival. *Paper read before the Society of Arts.*

Adulteration of Dyes.—W. STEIN states that red dyes should colour neither soap and water nor lime-water, nor should they become yellow or brown after boiling; this test shows the presence or absence of Brazil-wood, archil, safflower, sandalwood, and aniline dyes. Yellow dyes must stand boiling with alcohol-water and lime-water; madder yellow is the most stable, annatto and turmeric the least, whilst fustic is intermediate. Blue dyes should not give a red tinge to alcohol, nor should they decompose on boiling with hydrochloric acid. Purple dyes also should not colour alcohol red; the best are made of indigo, cochineal, or purpurine. Orange dyes should colour neither water nor alcohol on boiling; green dyes, neither alcohol nor hydrochloric acid. Brown dyes should not lose their colour on boiling with water, nor on standing in contact with alcohol. On boiling black dyes with carbonate of soda, a brown tinge is developed with pure gall nut dyes, a greenish or blue colour if a basis of indigo have been communicated; on the other hand, on boiling with hydrochloric acid a red colour is developed when logwood without an indigo basis has been used, and a blue colour when indigo has been used. *Journal of the Chem. Soc. from Dingler's Pol. Journal, ccx.* 215.

Use of Iron Rollers Electrotyped with Copper for Calico Printing.—T. SCHLUMBERGER states that the value of a roller of pure copper is from 2½ to 3 francs the kilogramme. A new roller weighs about 70 kilogs., and cannot be used when its weight is diminished to 25 or 30 kilogs. by successive engravings and turnings, each of which latter reduces the weight by some two kilogs. and diminishes the diameter by a little more than the depth of the design. By the substitution of cast-iron for copper a great saving is effected in the cost of the rollers; an iron roller of the ordinary size costs only about 30 centimes per kilog., and when electrotyped with copper ready for graving only costs about 100 francs per roller, the expense of re-covering with copper being about 10 to 20 francs.

Considerable difficulties are experienced in the preparation of the electrotyped rollers, however, so that the question of the practicability of their use is as yet not definitely settled; these difficulties are mainly due to the following considerations:

1. It is necessary that a perfect adherence should occur between all points on the surface of the cast-iron roller and the layer of copper deposited thereon; the production of this perfect contact is, however, excessively difficult, and indeed impossible as yet in the case of rollers intended for certain special styles: sometimes the rollers are subjected to very great pressure, amounting to 10,000 kilogs. or more; hence the layer of copper has a tendency to undergo lamination and to become detached from the core of iron; a most careful cleansing of the surface of the iron is requisite, so that its surface may be absolutely free from scoriæ, dust, sulphur, &c.; the more perfectly this condition is fulfilled the better is the chance of success.

2. The deposited copper must not be brittle or hard, otherwise it may scale and chip off; neither must it be too soft, else it is readily scratched; only great experience can give the exact methods that yield the best results in the matter of composition of baths, temperature, strength of current, nature of battery, &c.

3. Some mechanical difficulties are experienced in the setting up of hollow cast-iron cylinders which are not noticed in the case of solid copper rollers.

4. Careful handling of the rollers is requisite, otherwise their ends are injured and separation of the iron and copper brought about at these extremities.

5. The rollers having been used once must be re-covered with copper, and it is possible that the different sorts of successive deposits thus produced may affect the accuracy of the next engraving, the permanency of the deposit, &c.

6. The cost of all the manipulations thus rendered necessary must not amount to too large a sum.

Many of these practical difficulties have been overcome and several hundred rollers have been prepared and used with very satisfactory results, especially for treatment with *aquafortis*, and with the pantograph, the coppering and engraving being alternately repeated five or six times without any inconvenience. *Bulletin Soc. Ind. Mulhouse, March*, 1874, *p.* 116.

G. SCHOEFFER states that the chemical committee of the Société Mulhouse have examined the process referred to by Schlumberger (*supra*); the first attempts in this direction were made years ago in England by Lockett, since when many others have attempted to deal with the question, but uniformly with only partial success. The following difficulties are met with in the experience of a large number of manufacturers collectively.

The copper and iron do not adhere together sufficiently to avoid the difficulty of preventing separation of the metals under the considerable pressure required with certain kinds of styles; solid copper rollers are much more hard and dense owing to the frequent hammerings and rollings they undergo during manufacture. Although the rollers can always be kept of a uniform diameter, yet the saving is less than was at first imagined, as it costs almost six times as much per kilogramme for electrotyped copper as for ordinary copper, whilst the disused solid copper rollers are intrinsically worth as much per kilogramme as the new ones, or nearly so; the iron cylinders, however, have but little value. Solid cylinders easily bear the requisite pressure, whilst cast-iron cylinders are apt to bend and even to break; when damaged, a solid cylinder can be repaired by burnishing or by the introduction of a plug of metallic copper, neither of which operations can be satisfactorily effected with the electrotyped iron cylinders. When the same patterns are tried on both kinds of rollers it is found that the solid cylinders last better as they resist more.

The following process is recommended for coppering the rollers. In the first place the cylinder is thoroughly washed with an alkaline solution, washed with a large bulk of water, and filed perfectly bright with a suitable file; every trace of rust or stain must be thus detached, and when this is accomplished, care must be taken neither to breathe on the clean surface nor to touch it; the polished and clean roller is then placed in one of the following alkaline baths:—

No. 1.

Mixture A.	Water . . .	12 parts.
	Sulphate of copper .	1 „

Mixture B.	Water . . .	16 parts.
	Cyanide of potassium.	3 „
	Carbonate of soda .	4 „
	Sulphate of soda .	2 „

A and B are thus mixed together when complete solution has taken place in each case.

No. 2.

Mixture C.	Water . . .	10 parts.
	Ammonia . . .	3 „
	Acetate of copper .	2 „
Mixture D.	Water . . .	16 parts.
	Cyanide of potassium.	3 „
	Carbonate of soda .	4 „
	Sulphate of soda .	2 „

C and D are mixed together after complete solution has taken place in each case.

The roller remains in one of these baths for twenty-four hours, a battery of six elements being used ; at the end of this time a fine, closely adherent pellicle of copper is thrown down on the iron ; this is washed and rubbed with fine pumice stone, being replaced in the bath if the iron becomes bared anywhere : the thinner this first coating is (provided it be perfectly continuous), the more powerful is the adhesion ultimately.

After washing and brushing, the roller is well washed, and then rinsed with acidulated water and plunged quickly into the following acid copper bath :—

Sulphate of copper solution, at 20° B .	150 litres.
Sulphuric acid	¼ litre.

and allowed to remain for several weeks, a current from a battery of four cells being used, at a temperature of 15° to 18° ; a deposit about ¼ millimeter thick is thus obtained. The battery may be conveniently constructed by placing porous cells in the bath, each containing dilute sulphuric acid and a rod of zinc, the solution being replenished by the addition of sulphate of copper crystals, and of lumps of metallic copper ; the evolution of nitrous fumes is thus avoided. *Ibid. p.* 120.

Leather.—FAIRE and SAUVAGE patent the preparation of leather from tripe, intestines, and other animal membranes ; these are soaked in milk of lime whilst still fresh, then washed and immersed in water, and finally in a paste made of starch and white of egg. The substance thus formed may be used for glove-making, &c. ; the materials can also be tanned or curried. *Bull. Soc. Chim. Paris, xxi.* 336.

Charcoal as a Depilatory.—ANDERSON finds that a thin paste of water and animal, or even vegetable, charcoal, is most effective as a depilatory ; hides immersed therein are completely divested of hair in a few days : whilst the leather made from hides thus treated, is superior to that prepared by the ordinary lime process. *Dingler's Polytech. Journal, ccx.* 398.

§ 4. *Food and Sanitary Matters.*

Extract of Beef.—E. REICHARDT gives the following analysis of extract of beef from Monte Video, showing that the composition varies but little from year to year :—

	1870.	1873.
Soluble in 80 per cent. alcohol .	81·00	80·13
Water (loss at 110°) . . .	16·50	15·92
Fat and albumen	Nil.	Nil.
Nitrogen	9·78	9·47
Total ash	21·36	21·30
Phosphoric acid	6·10	6·00
Potash	8·87	9·00
Soda	2·30	2·26

Journal of the Chem. Soc. from Arch. Pharm. [3] *iii.* 399.

Curing and Packing of Hams.—S. ATKINSON describes the following improved modes of curing and packing hams and bacon :

Hogs after being killed and dressed are hung in a cooling room at a temperature of about 40° F. for thirty-six hours. The hams and bacon are then laid singly on the floor of a large tank or vat (from which water can drain) and covered with small broken ice and salt mixed ; this is covered with alternate layers of meat and broken ice and salt until the tank or vat is full. The hams and bacon are allowed to remain in this state for about twenty-four hours, at the expiration of which time they are moved and placed in pickle of full strength, in which they are allowed to remain for about twenty-four hours. They are then drawn out and laid in rows on the floor of a cellar cooled to about 40°, having been sprinkled lightly with saltpetre and well covered with coarse salt. After lying in this position for about seven days they are removed, freshly covered with salt, and allowed to lie in a similar position for about seven days longer, when they are again removed, resalted, laid down, and left for about sixteen days more, at the expiration of which time (thirty days from the period of first going into salt) the hams or bacon may be considered fully cured.

To prepare the meat for packing, it is well brushed in clean cold water and allowed to drain for twenty-four hours, then weighed and all moisture carefully wiped off with a dry cloth, after which it is sprinkled or rubbed over with fine ground alum. The hams are put into paper bags, or rolled in best quality of Manilla paper, or better, rolled tightly in straw boards, made pliable by being soaked in a solution of alum so as to conform to the exact shape of the meat, thereby excluding the air and rendering them impervious to moisture after becoming dry.

Influence of Nitrogenous Manures on the Growth of Cereals. LAWES and GILBERT give the following results :

1. When either ammonia-salts, or nitrate of soda, or nitrogenous organic matter in the form of rape-cake, or farmyard manure, was applied for either wheat or barley, a considerable proportion of the nitrogen so supplied remained unrecovered in the increase of the crop for which the manure was employed ; nor was the whole recovered in many succeeding crops.

2. When ammonia-salts were applied in the autumn for wheat, a much less proportion of their nitrogen was recovered in the increase of crop, than when they were applied in the spring for barley or for oats.

3. Analysis of the soils to the depth of 27 inches, showed that there was a considerable accumulation within that depth, of the nitrogen of manure which had not been recovered in the increase of the crop ; but that a still larger amount remained to be otherwise accounted for.

4. Analysis of the drainage waters from the experimental wheat plots showed that they contained a large amount of nitrogen in the form of nitrates ; that the quantity of nitrates in the drainage was the greater the greater the amount of ammonia-salts applied as manure ; and that (after autumn sowing), the quantity was very much greater in the winter, than subsequently in the spring and summer.

5. The analysis of the drainage waters further showed—that the winter drainage, after sowing ammonia-salts in the autumn, may often contain from two to three parts (and sometimes much more) of nitrogen (as nitrates and nitrites) per 100,000 parts of water. Calculation showed that, for every one part of nitrogen per 100,000 parts of drainage, there will be a loss of 2¼ lbs. of nitrogen per acre for every inch of rain passing beyond the reach of the roots. In one case analysis showed 7·841 parts of nitrogen per 100,000 parts of drainage, corresponding to a loss of 17½ lbs. of nitrogen per acre, provided an inch of rain passed as drainage of that strength.

6. A given surface of soil possesses much less capacity of absorption for nitrate of soda, or its products of decomposition, than for the ammonia of ammonia-salts. Consequently, heavy rains soon after sowing would carry off in the drainage water more nitrogen from a dressing of nitrate of soda, than from a corresponding dressing of ammonia-salts. In one case, after a heavy dressing of nitrate of soda in the spring, the drainage-water contained 5·83 parts of nitrogen per 100,000 of water, corresponding to a loss of 13 lbs. of nitrogen per acre, per inch of rain so passing.

7. Owing to the much less loss by drainage in the case of spring than of winter sowing, there was not only more increase in the immediate crop from a given amount of nitrogen applied in the spring for barley (or oats) than in the autumn for wheat, but there was also much more effect upon succeeding crops, from the at first unrecovered amount, in the case of the barley than in that of the wheat.

8. It is probable that the whole of the nitrogen supplied as manure in ammonia-salts, or nitrate of soda, is either recovered in the immediate increase of crop, retained in the soil in a very slowly available condition, or drained away and lost.

9. Owing to the slow decomposition of the nitrogenous organic matter of rapecake and farmyard manure, their nitrogen is less rapidly available than that of ammonia-salts or nitrate of soda ; but, so far as can be judged from the direct experiments on the point, it would appear to be, at the same time, less subject to loss by drainage.

10. Certain important mineral or ash-constituents of manures (potash and phosphoric acid for example), are, at any rate in the case of the heavier soils, almost totally retained by them within the range of the roots, and they are found to be very lasting in their effects upon succeeding crops, provided there be a sufficient available supply of nitrogen within the soil. *Journal of the Agricultural Society.*

Manufacture of Sugar.—F. GRIFFIN states that large quantities of good sugar are produced in Canada and the Northern United States from the sap of the sugar maple, which attains a height of 60 or 80 ft. The trunks are tapped about February, and the collected sap is boiled down to granulation and drained. The produce is consumed at home, the raw sugar refined in this country being chiefly obtained from the sugar-cane. This is a gigantic reed belonging to the family of the grasses, which grows to a height of from 10 to 15 ft., and is propagated by cuttings taken from the top-joints of the stem. Like other grasses, the sugar-cane is stiffened by a hard siliceous cuticle or rind, and is further strengthened by annular joints or knots at short intervals, from which spring the leaves, and in the cuttings the rootlets beneath, and the young plant above. These cuttings are set in small trenches, about 8 in. deep, and at the least 5 ft. or 6 ft. between the rows, but they are now more generally laid 4 ft. to 6 ft. apart in shallow furrows, formed by a small plough. The leaves are large and drooping, 3 ft. to 5 ft. in length. The Tahiti cane, from which the fine Mauritius sugar is made, has to a great extent replaced the common or "Creole" cane from India, as it is hardier, quicker, and more luxuriant in growth, and affords a better yield of sugar. When the leaves have fallen off and the stalks become yellow (which is in ten to twelve months for the Tahiti, and twelve to fifteen or sixteen for the Creole cane) they are cut off close to the ground, and immediately carried to the crushing mill for the expression of the sap, which constitutes 85 to 90 per cent. of the total weight when fresh, the woody fibre and rind not exceeding 10 to 15 per cent. The mill consists of three or five large iron rollers kept slowly revolving as the canes are drawn and crushed between them. All this machinery (the fly-wheel more especially) requires to be very strong and massive, from the irregularity of feeding and action causing much jerking and strain on it. These mills were formerly driven by the wind, but this uncertain motor is now replaced by steam, the fuel for raising which, as well as for the subsequent operations, is chiefly the crushed cane dried in the sun or by the waste heat of the fires. For each horse-power of the engine about 100 gallons per hour of expressed juice is obtained. This is an opaque, frothy, yellowish liquid, of a faint but agreeable balsamic smell, and containing about one-fifth of its weight of sugar, which is all crystallizable. This is first clarified and rendered more stable by heating at once with a small quantity of lime made into a cream with water, and called "temper." This coagulates and partly carries down the albumenoid nitrogenous matter, which would speedily give rise to fermentation. The clear yellow liquor is heated more and more strongly in a series of pans, the calcareous scum which forms being carefully skimmed off, and it is then boiled down till on cooling in large tanks it will "grain," or imperfectly crystallize. The moist mass so obtained is drained for several weeks, to allow the liquid molasses to run off as much as possible before packing in hogsheads or bags for shipment. The boiling down used to be carried on with little care, and at a high temperature in open pans, whereby much molasses was formed at the expense of the sugar, rendering it dark and clammy, thus deteriorating its value and causing great loss of weight by leakage during the sea voyage. This wasteful system has been superseded in Java, Mauritius, Havana, and many of our own colonies by the use of the vacuum-pan and other improved processes, whereby a very superior class of sugars is produced, more profitable alike to the producer abroad and the refiner at home.

The maximum of bad manufacture is reached in the Jaggary made by the native Hindoos by methods unaltered from immemorial times. The cane is crushed in a rude wooden mill resembling a huge mortar and pestle, and the juice is simply boiled down in earthen pots till it forms a nearly solid half-burnt mass, containing only 73 to 77 per cent. of crystallizable sugar.

The Fiji Islands may some day yield a supply of raw sugar, as the cane thrives well in them; the sugar is badly made there at present, so that it is of low quality, and marks only 83 per cent.

By far the greater part of the sugar consumed on the Continent is made from beet-root, which in the fresh state contains about 12 per cent.; a considerable amount of this sugar (last year 26,000 tons), is imported into this country, of far inferior quality to that produced from the cane. The sugar is accompanied in the expressed juice by considerable quantities of various nitrogenized principles, which are estimated to amount to 11¼ per cent. of the weight of the dry beet, or nearly one-sixth as much as of the sugar itself. These nitrogenous matters induce fermentation and all kinds of chemical changes, and can only be eliminated by the highest refining. Moreover, even the manufactured beet-sugar is saturated with an essential oil of a most offensive glue-like smell, very disgusting when the sugar is in quantity, and difficult to get rid of entirely.

The manufacture of beet-sugar took its rise in the exigencies of France when commercially isolated during the wars of the first Napoleon, and it has attained to huge proportions. The production in Europe in 1843 was only 55,000 tons; ten years later (1853) it had nearly quadrupled, being 200,000 tons; in 1863 it was 452,129 tons, more than double; while last year (1873) it had reached the immense total of 1,142,896 tons, more than one-third the amount of cane-sugar produced by the whole world, which is estimated to have been that year a little under three million (2,954,722) tons. This extensive cultivation affords large agricultural employment, and keeps down the price of sugar abroad, hence it is a great boon to continental Europe.

Crude sugars, as imported, vary much in their saccharine richness, which ranges from about 75 to 98 per cent. of pure crystallizable sugar. Practical buyers acquire by experience considerable skill in judging of the refining value of a raw sample from its colour, feel, smell, and taste; its hard, sparkling "grain," or soft, dull character; but even their conclusions are sometimes found to be very erroneous when brought to the touchstone of scientific analysis. Hence the accurate valuation of the raw sugars offered in the market is of paramount importance and demands the closest attention. *Paper read before the Society of Arts.*

Sugar from Beetroot.—HEEREN states that the process known as "diffusion" has great advantages over the older methods of extraction by pressure, maceration, and centrifugal-machining. A very pure syrup is obtained by this process, which also yields a better and more nutritious cattle food derived from the residue; moreover a more concentrated juice is obtained and the extraction is more complete, whilst great economy in labour, machinery and fuel is produced, and no press-cloths required.

This process is carried out thus: the beets are sliced and placed in "diffusers" or cylindrical iron vessels worked in series after the fashion of blackash lixiviation vats; water at 50° C. is poured on to the beets and allowed to rest on them for some time; after the maceration has been carried on for some time the liquor is run off and the residue washed with water, either warm or preferably cold. *Journal of the Chemical Society, from Dingler's Polytech. Journal, ccix.* 56.

Composition of Commercial Sugars.—F. GRIFFIN gives the following results as to the average per-centages of raw sugars as determined by some thousands of careful polarimetric observations. The most constant in quality is Java, which seldom falls below 96 and ranges from that to 98 or even higher. Fine Mauritius ranges from 95 to 98, but the syrupy kinds hardly average more than 90 or 91, some being as low as 86 or 87. Havana varies widely; the ordinary kinds generally run from 91 to 95, 93 being a very frequent per-centage, but some of the finer kinds rise to 96 or 97, and exceptional boxes are nearly pure, showing 99 or even 99¾. The second class, as West India (Demerara, Barbadoes, Trinidad, Cuba, &c.), and the still inferior Brazilian sugar, (Pernambuco, Bahia, Paraiba, and others), vary so much, even in different parts of the same cargo, that it is almost impossible to give a special average for each: collectively they range from 80 to about 93; only exceptionally good cargoes exceed 90 per cent. however, in actual out-turn. It is noteworthy that whilst fine sugars, such as Java, Mauritius, or Havana, generally land nearly or quite equal to the shipping sample by which they were bought, inferior kinds are usually considerably below the sample, the more so the lower the quality, the depreciation amounting to 2, 3, or even 4 per cent. This arises chiefly from deterioration during the voyage; such sugars are always moist and acid, conditions highly favourable to the change of cane sugar into uncrystallizable sugar, especially when aided by a tropical temperature and the damp close atmosphere of the hold of a ship.

Raw sugar contains considerable quantities of woody fibre from the crushed cane, which has not been separated by filtration; often much gritty sand, innumerable sporules of fungus, colonies of the sugar-mite, nitrogenous matter, and treacle, or glucose, in its different forms. The woody fibre is simply indigestible; the sand attracts attention when the sugar is dissolved in tea or otherwise, and is popularly supposed to be added by the grocer. However, low sugars when imported frequently contain a notable amount of sand, whose accidental introduction cannot be readily accounted for. In a small cargo 12 tons of sand were once found. Stones, lumps of rock, and old iron; in one instance a cannon-ball; in another a set of slave-manacles, have been found in West India hogsheads, to be paid for as so much sugar. *Fungus spores* are deleterious from the extreme rapidity with which, under suitable conditions, they develop into a spreading vegetable growth; but more objectionable still is the animal product of the sugar, the *acarus sacchari*, or sugar-mite. This is oval in shape, with eight jointed and spiny legs

armed with formidable hooks, and altogether similar to the itch-insect, than which, however, its organization is still more formidable and forbidding. It seems to burrow under the skin in the same way, producing the irritating pustular disease known as "grocer's itch," from its attacking those who are constantly handling raw sugars. Such living beings can hardly fail to be injurious when swallowed, especially as they are difficult to kill. It is the nitrogenous matter which supports the existence alike of fungus-germs and acari, and the relative abundance of these is a pretty correct measure of the proportion of the albumenoid principle. Most nitrogenous bodies are not only unstable and prone to decay themselves, but impart their own changeability to other organic materials with which they may be in contact. Hence a solution of brown sugar will speedily ferment and turn sour, and jam made with it, unless boiled down hard, will quickly spoil, although pure sugar is one of the best preservatives. The treacle is the source of the coarse saccharine flavour which attracts the uneducated palate, and quite as much as fancied economy renders raw sugar popular with certain classes; but the inferior kinds are far from cheap, as they are extremely heavy.

The white moist sugar of the shops, technically called "pieces," is free from woody fibre, sand, fungus spores, or acari, since it has been refined; but it is often moist and clammy, so as to weigh heavy in proportion to its sweetening power, and as it is frequently made in part from raw beet-sugar, it is apt to retain traces of its offensive volatile oil, and its abounding nitrogenous matters, rendering it liable to ferment. The absolute amount of impurity present in loaf-sugar varies very greatly, and ranges from about 2 per cent. in the lowest samples to about ·5 per cent., or possibly in very fine samples, ·25. The only way of comparing different classes of sugar and the amount of nitrogenous matters contained in them, which will induce chemical changes in the blood or in vegetable matter, as, for instance, in preserved fruit, is not by means of chemical tests or the balance—because the whole may be imponderable—but by carefully trying the substances against each other; if it be then found that one slightly impure substance sets up fermentation, and the same when perfectly purified does not, a practical solution would be arrived at. *Journal of the Society of Arts, May 15th*, 1874.

Inorganic Constituents of Wheat and Barley.—LAWES and GILBERT find that the following amounts of inorganic constituents are contained per acre in average crops of the annexed weights:—

Wheat, 30 bushels, of 60 lbs. per bushel = 1,800 lbs., and 3,000 lbs. straw = 4,800 lbs. total produce;
Barley, 40 bushels, of 52 lbs. per bushel = 2,080 lbs., and 2,500 straw = 4,580 lbs. total produce.

	In Corn.		In Straw.		In Total Produce.	
	Wheat.	Barley.	Wheat.	Barley.	Wheat.	Barley.
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
Nitrogen	32	33	13	12	45	45
Phosphoric acid	16	17	7	5	23	22
Potash	9·5	11·5	20·5	18·5	30	30
Lime	1	1·5	9	10·5	10	12
Magnesia	3·5	4	3	2·5	6·5	6·5
Silica	0·5	12	99·5	63	100	75

"*Report of Twenty Years' Experiments on the Growth of Barley.*"

Tea Adulteration.—A tea-taster and late tea-inspector writes as follows:—"Tea adulteration must be divided into two parts, viz., injurious adulteration and harmless adulteration. The first consists in imparting to the article foreign poisonous matter, such as steel filings, Prussian blue, &c. &c. &c. Prussian blue is used to face, or produce a good-looking surface on common green tea; and, as the public used to prefer bright green tea, this adulteration was so common, that at least one-third of the green tea imported was "faced." Harmless adulteration consists in mixing with tea harmless matters and ingredients, such as "stalks," which are imported in large quantities from China, and which is the tea shrub after the leaves are picked, broken up small, and mixed with leafy tea. This increases the weight, and causes no harm to the consumer, save the imposition of the vendor of the article as "pure tea."

Another article of adulteration is "brick tea." It must be understood that the Chinese press the tea into the chests with their feet, and what is spilt by being continually walked upon, together with the moisture of the feet and earth, becomes hard and solid, and is sold in cakes as "brick tea." This is ground into powder, and thrown among good leafy tea, and imitates dust. It is seldom, if ever, that injurious matter is introduced into tea by the wholesale dealers in this country. A certain person once bought up the used tea, or the leaves, of large establishments. These were placed in hot pans, and the heat caused the leaf to roll up again, and except by the smell it could not be recognized. This is an old trick, and often practised. While acting as inspector to a firm of tea-brokers in the City, I had occasion to inspect a parcel of tea sent for cheapness in an unseaworthy vessel from China. The effluvia of the bilge water, of which there must have been a large quantity in the vessel, had so impregnated the tea as to render it, in my opinion, unfit for consumption. I informed the merchant and broker of the fact, but notwithstanding the tea was sold at the London Commercial Sale Rooms, and must have been consumed by this time, though in my opinion it was certainly likely to produce illness, if not disease in the consumer.

Adulteration has been so common, and such filth sold as tea, that I may add that I had, and I believe I have now, a sample of "tea," sold as Fine New Season Gunpowder, that was the refuse of a pig's-stye mixed with green dust, and faced with Prussian blue. Experience has plainly shown me that nothing short of inspecting tea on its arrival in port will stop adulteration injurious to the consumer."—"*Echo*," *June 8th*, 1874.

Character of Good Potable Water.—F. FISCHER states that good water should be perfectly clear and tasteless, and devoid of smell; its temperature should not vary more than a few degrees (from about 6° to 12°) throughout the year; it should contain very little organic matter, and no organized beings, such as bacteria, ova of entozoa, &c., and should be free from ammonia and nitrous acid, and should contain only a small amount of sulphates, nitrates, and chlorides; moreover, it should not be too hard, and should contain but little magnesian salts.

The following amounts are about the maxima permissible per litre:—

Organic matter, 0·040 gram; *i.e.* not more than what is equivalent to 0·008 gram of permanganate of potassium.

Chlorine,	0·0355 gram	(1 milligram equivalent)
Nitric acid,	0·0315 „	(1·6 „ „)
Sulphuric acid,	0·098 „	(2 „ „)
Magnesia,	0·098 „	(2 „ „)
Lime,	0·112 „	(4 „ „)
Hardness,	16·8 German scale.	

Journal of the Chem. Soc. from Journal Pract. Chem. [2.] *viii.* 123.

Calcium Iodate as an Antiseptic.—E. SONSTADT finds that calcium iodate possesses remarkable antiseptic properties, preserving urine for weeks, without the emission of offensive odours; albumin and many other readily decomposable substances are similarly preserved fresh for months, by the addition of a small quantity of the salt. The rancidity of salt herrings may be removed by soaking in water, so as to wash out the salt, and then immersing in a solution of iodate. Fresh butter keeps for three weeks in a solution of the salt, whilst rancid butter is considerably improved by this treatment.

Taken through the stomach by the human subject, an increase of appetite is produced, the salt acting as a tonic, like quinine; it also appears likely to be useful in infectious diseases; toothache from carious teeth is greatly benefited by the use of the salt, whilst an incipient attack of typhoid fever was cured by a dose 0·1 gramme. *Chemical News, xxviii.* 297.

§ 5.—*Fuel, Gas, Illumination, Photography, &c.*

Use of Wet Coal as Fuel.—No advantage is gained by the practice of wetting coal so as to cake it together; on the other hand, a loss of heat is always occasioned, and the temperature of the fire is lowered. *Dingler's Polytech. Journal, ccx.* 233.

Improved Method of Evaporating.—UNGERER proposes a novel device for economising heat in evaporating liquids, where great purity of the residue is not wanted. A perforated cistern is placed on the top of a perpendicular shaft or tower, and a considerable number of wire or other ropes or rods are suspended from the bottom of the cistern and reach down through all the length of the tower. The liquid to be evaporated is first conducted to the top of the tower and then allowed to run down through the perforations in the bottom along the ropes at a speed which must be regulated according to circumstances. Hot air or the products of combustion proceeding from a furnace enter the tower near its base and escape through an opening near its top, meeting on their way the liquid spread over the immense surface presented by the ropes, and thus concentrating the same by evaporation, more or less, according to the heat of gases and the speed at which the liquid is allowed to run down the ropes. A tank is placed at the base of the tower in order to

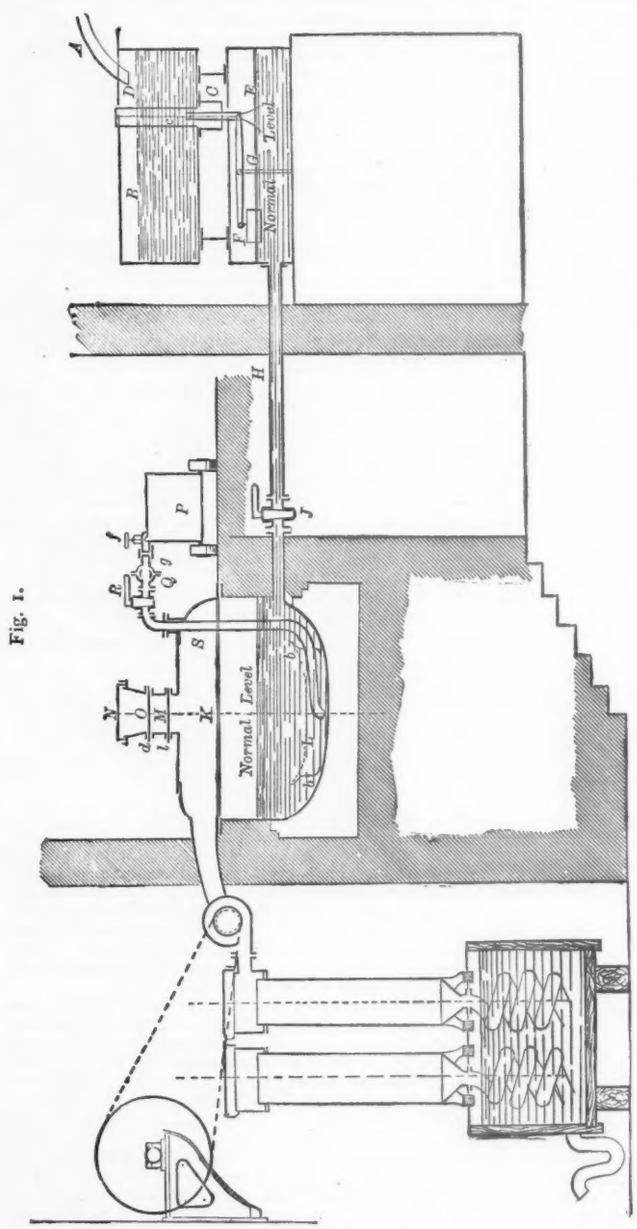


Fig. 1.

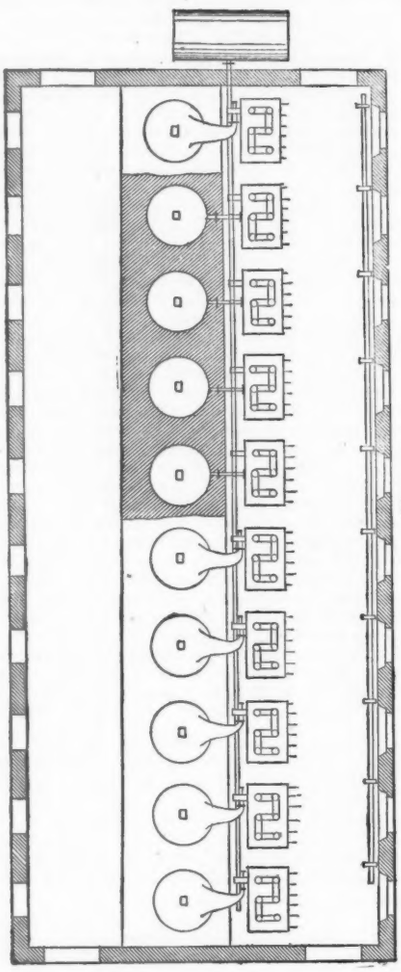


Fig. 2.

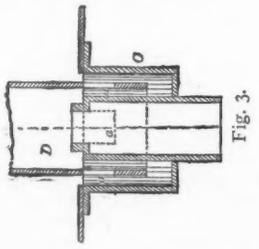


Fig. 3.

collect the concentrated liquid, and from this it is removed either occasionally or continuously.

The process is specially applicable for concentrating alkaline lyes which have served for boiling wood, straw, esparto grass, and similar materials used for the production of paper pulp. *Dingler's Polytech. Journal.*

Continued Distillation of Mineral Oils.—H. FUST has devised an apparatus which permits of uninterrupted working, and where the level of the liquid in the stills remains constant.

Fig. 1 represents the apparatus independent of its arrangement in the factory, which is shown in fig. 2. The liquid to be distilled flows through the pipe, A, into the basin, B; to keep this latter constantly full is the task of a special workman. Below B is a construction, C, intended, in connection with the float, F, to keep up a constant level, which is thus effected: Below the basin, B, is another one, E, which communicates through the pipe, H, with the still, K; this latter and basin E have therefore their liquids always at the same level. The float, F, in basin E, is connected by means of the lever, G, and the vertical rod, C, with the pipe, D, the lower end of which (see fig. 3) enters into the annular rim of the apparatus, C, filled with mercury; this lower end of D is provided with the openings *a*, *a*, *a*. The float, F, and pipe, D, are now so connected, that the edges of the openings, *a*, *a*, *a*, just touch the level of the mercury when the still, K, and consequently also basin E, have their normal level. If now, in course of the distillation, the level in the still falls, and therefore also that in E, then the float, F, is also lowered; through this pipe D is lifted up, the outlets *a*, *a*, *a* rise above the mercury, and thus permit a flow of liquid into E. As soon as in E the normal level is reached, the openings of D come again into contact with the mercury, and thus any further supply of liquid is arrested.

The chemical reagents required for the purification of the oils are introduced through the box over the manholes of the still. The cover N is taken off, the necessary amount of chemicals placed into the upper space O, the cover N again put

on, and the ventil *d* opened, through which they fall into the space M, wherefrom, after closing at *d*, they are permitted to drop through a second ventil *l* into the still. Here the chemicals drop upon a perforated false bottom L, which rests on four legs *b*, *b*. The manhole is large enough to permit the taking out of this bottom. The cleaning of this bottom is performed on Sundays.

The removal from time to time of the residues of the distillation is effected in the following manner: The firing of the still is diminished for a short interval, in order that the residues, foreign admixtures, &c. may fall to the bottom. An air-tight waggon P, provided with an air-pump, is attached through a double matrix *g* to the joint Q, which is fixed to a tube S leading into the space between the false and the real bottom of the still, and which tube is closed by the tap R. As soon as the waggon is attached, the workman opens the tap R and the ventil *f*, and exhausts the waggon. The latter being filled, R and *f* are closed, the waggon detached from Q and taken away to be emptied. The frequency of such evacuation of the still depends on the size of the latter; once about every twelve hours would in most cases be advised.

The collection of the products of distillation takes place by fractional condensation. The arrangements for this purpose are easily understood from the diagram in fig. 2. This drawing shows also the best way of setting up the distilling apparatus in a factory. *Dingler's Polytech. Journal, ccvii.* 293.

Purification of Coal Gas.—M. VOLLMAR finds that a bog iron ore found at Budin, a few miles south of Teplitz, Bohemia, is an advantageous material for coal gas purification, especially after being treated with ½ to 1 per cent. of lime; this substance has been used as ochre for some years past, and contains 70 to 80 per cent. of ferric hydrate. Ordinary gas purifying mixture (100 parts of sulphate of iron and 25 of lime ignited together) costs 3*s.* 3*d.* per cwt., whilst this ochre can be supplied at Randnitz for 1*s.*, and is besides twice as rich in iron oxide. When completely saturated with sulphur the material can be used as cement, being dried, ground to powder, and mixed with fine iron filings. A good cement is also obtained by melting it with half its weight of sulphur; the product dissolves(?) in boiling paraffin oil, and the solution can be used instead of pitch or asphalt for roofs, &c., being no more inflammable than ordinary asphalt. The author proposes to call this bog iron ore *Sidro-theion. Chem. Soc.'s Journal, from Dingler's Polytech. Journal, ccx.* 191.

Products of Peat Distillation.—B. NIEDERSTADT gives the following analysis of various kinds of peat.

A Dark brown lignite.
B Dark grey charcoal-like material.
C Black shiny coal.
D Black-brown lignite.

	A	B	C	D
Carbon	51·2	58·9	70·0	60·3
Hydrogen	4·2	4·0	3·2	4·8
Oxygen	32·3	20·8	17·6	20·2
Nitrogen	0·2	0·1	0·1	0·1
Ash	1·8	5·9	5·5	3·2
Moisture	10·3	10·3	3·6	11·4
	100·0	100·0	100·0	100·0

On dry distillation these substances give a heavy tarry distillate together with an aqueous liquor.

		A	B	C
Percentage of Tar		4·54	4·13	4·09
Do.	Aqueous distillate	54·07	55·33	47·92

Carbolic acid was obtained from the heavy portion of the distillate, whilst a crystalline body much resembling paraffin was obtained from the lighter portions. *Journal of the Chem. Soc. from Chem. Centr.* 1873. 154.

Manufacture of Anthracene.—F. VERSMANN states that the usual processes of tar-distilling are carried out as usual, and the last 10 or 15 per cent. of the products of the distillation are set aside and allowed to stand for some weeks, when a crystalline deposit of solid hydrocarbon separates; this is freed as much as possible from the adherent oil by filtration, pressing, or other mechanical means, when the residue, more or less dry and more or less impure, is ready for sale.

In the early days of anthracene—and that is but four years ago—the alizarine makers were well contented to get anthracene of any quality, however low in percentage, because the success and very life of the new dye depended upon the possibility of getting large quantities of a hitherto unknown article. At that time the alizarine maker bought what he could get, often perhaps not knowing himself the value of the article bought; but he did so unwillingly and only of necessity.

The manufacturer of alizarine has not at his disposal the necessary plant required for the purification of crude anthracene; at all events he loses much time, and has no use for the oily residues resulting from the purification.

The tar distillers, on the other hand, can always use these by-products along with their other oils. They ought to take the greatest care in the pressing of the well-filtered and drained anthracene, by using powerful hydraulic presses and by pressing, first cold, and then hot, as strongly as possible. Such crude, well-pressed anthracene is readily powdered and passed through a sieve, and in this state of fine division it may be treated with petroleum spirit, boiling between 70° and 90° C., and after sufficient washing it may again be submitted to strong pressure.

The price of crude anthracene of good quality is sufficiently high to induce the tar distiller to study carefully the manufacture of the article, and to devote all his care to it.

Few distillers are aware of the profit to be derived from purifying their crude product and thus obtaining a high-class article. A new class of manufacturers has sprung up, viz., anthracene purifiers, who buy the crude anthracene and supply the consumer with an article of the desired purity. Of these anthracene purifiers there are several in Germany and at least one in England; and nothing could speak more strongly in favour of the argument, that the first manufacturer should also be the purifier, than the fact that other people find it profitable to take up the purification as a separate business.

England is the great tar-producing country, and the principal supply of anthracene must always come from here. The nine London gasworks alone convert about 1,500,000 tons of coal into gas, and produce 12,000,000 gallons, or 60,000 tons, of tar a year. The gas companies have not been slow in profiting by this invention; the price of tar has already been more than doubled, an increase almost sufficient to reduce the price of gas a penny or twopence per 1,000 ft.

The yield of anthracene depends somewhat upon the quality of coal, and certainly also upon the degree of heat to which the coal has been exposed in the gas manufacture. Thus it is generally assumed that Scotch coals yield little anthracene, while South Staffordshire coal-tar is rich in anthracene.

Pure anthracene crystallizes in rhomboidal plates, which melt at 213° C. to a clear colourless liquid; it distils at about 360° C. Nearly pure anthracene may be obtained by melting a partially purified sample in a retort, and passing a strong current of air through it, when the anthracene is carried off, and may be collected in the shape of brilliant flakes, or it may also be purified by sublimation.

The author gives the following determinations of the solubility of pure anthracene in alcohol of different specific gravity, and also in some other solvents:—

		Per cent. Anthracene at 15° C.	
		By volume.	By weight.
Alcohol . . .	800	·472	·591
,, . . .	825	·424	·574
,, . . .	830	·408	·491
,, . . .	835	·397	·475
,, . . .	840	·387	·460
,, . . .	850	·360	·423
Ether		·858	1·175
Chloroform		2·587	1·736
Bisulphate of Carbon . . .		1·180	1·478
Glacial Acetic Acid . . .		·472	·441
Benzol		1·470	1·661
Petroleum		·291	·394

Paper read before the Society of Arts.

Manufacture of Charcoal for Gunpowder.—A. F. HARGREAVES finds that by suitably economizing the gases evolved during the carbonization of wood for gunpowder charcoal, 50 charges can be worked off with a consumption of only 56 lbs. of coal, the gases evolved from one set of iron retorts being burnt under the next set, and so on.

About 20 per cent. of charcoal is obtained; the more moist the wood, the less is the yield, carbonic oxide being formed by the action of the moisture on the charcoal. When freshly burnt the charcoal quickly absorbs oxygen from the air; this absorption generates heat, which sometimes rises to such an extent as to cause the ignition of the charcoal; hence "spontaneous combustion" is brought about; the higher the temperature of carbonization the more rapid is the absorption of oxygen. Three days after burning there is little or no heat evolution, the charcoal being then saturated with oxygen absorbed during the three days; stick charcoal does not absorb oxygen as readily as

ground charcoal; from 6 to 7 per cent. of moisture is also taken up by freshly-burnt charcoal during the first fortnight after burning; after this time no further absorption of moisture takes place. *Paper read before the Chemical Society.*

§ 6. *Miscellaneous.*

Waterproof Silk-paper.—R. JACOBSON prepares this by floating silk-paper for a short time in an aqueous solution of shellac in borax, and then drying in the air. By the addition of aniline dye stuffs to the borax liquor, any liquid tint can be given to the paper. *Dingler's Polytech. Journ. ccx.* 400.

Ivory-paper.—KOLLER mentions under this name a kind of glazed cardboard, which permits the easy rubbing out of pencil and even ink marks, provided these latter are not allowed to remain too long on it. No description is given as to its mode of preparation, or as to the ingredients used. Its use by school children in the place of slates is very strongly recommended. *Polyt. Centralbl.* 1873. 203.

Varnish for Wood Furniture.—NIEDLIG takes:

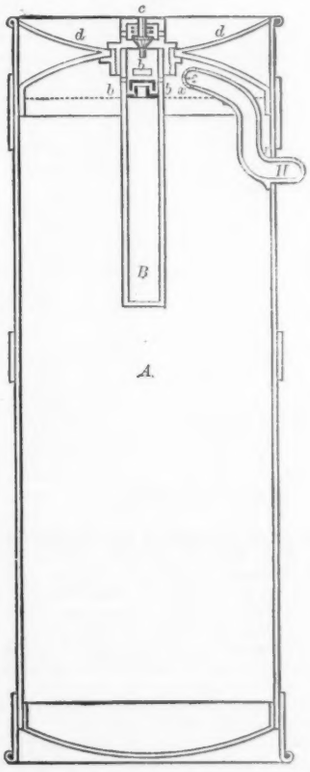
White wax . . .	8 pts.
Colophony . . .	2 „
Venetian turpentine . .	½ „

heats them gently with constant stirring, pours the mixture into a glazed stone pot, and adds, whilst yet warm, 6 pts. rectified oil of turpentine. After standing for twenty-four hours the mass is a soft buttery substance, and is ready for use.

The articles to be varnished must be carefully cleansed with soap and water, and then dried before applying the varnish. The polish obtained is less brilliant than that by shellac varnish, but it has a peculiar chaste appearance. *Dingler's Polytech. Journal, ccvii.* 1743.

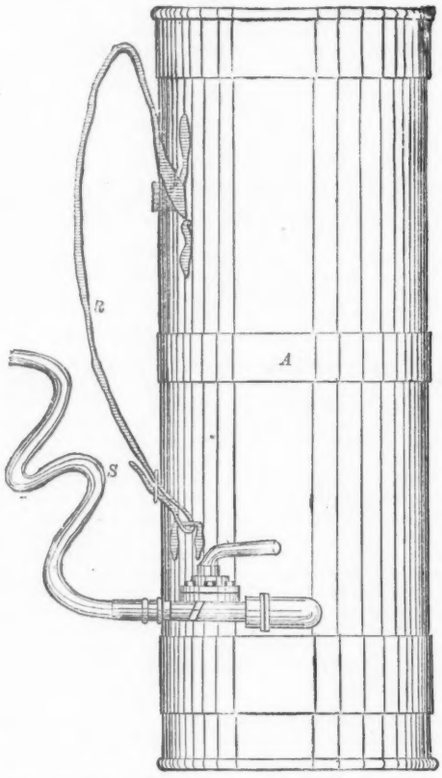
Portable Fire Extinguisher. ZABEL has constructed a portable fire-extinguisher, which seems to unite simplicity with great effectiveness. The apparatus, as shown in vertical section in fig. 1, is filled up to the mouth *b* of the lead tube B with

Fig. 1.



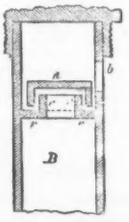
water, and also contains some bicarbonate of soda. The lead pipe B is filled to its top (fig. 3), *r r*— with sulphuric acid (of about 80 per cent. strength), with which also, the marginal groove *b* is provided; the lead cap *h*, set over the neck *r r*, dips into the groove and excludes thus the moist air from the sulphuric acid; this precaution is required in order to prevent the absorption of moisture by the acid, for should such absorption take place, it would bring about the overflow of the contents of the lead pipe, and thus discharge the apparatus. When the

Fig. 2.



extinguisher is to be employed, it is turned over, as seen in fig. 2, several times shaken up, put by means of the strap R on the back, and then discharged through the tap H. On inverting the apparatus the little lead cap on *r r* falls off, the sulphuric acid pours into the water, which fills the interior of the cylinder,

Fig. 3.



decomposes the bicarbonate, and thus saturates the water with carbonic acid gas and sulphate of soda. The quantity of bicarbonate taken is such as to yield carbonic acid capable of producing a pressure of $4\frac{1}{2}$ to $5\frac{1}{2}$ atmospheres. The apparatus is proof for a pressure of 14 atmospheres. *Dingler's Polyt. Journ. ccvii.* 113.

Adulteration of Caoutchouc.—The specific gravity of caoutchouc, 0·985, used to be considered as a criterion of its comparative purity, since all mineral addition would raise the above figure. HASENCLEVER states that large quantities of caoutchouc appear in the market containing considerable admixtures of sawdust. The decline in the application of caoutchouc for various industrial purposes is due to the prevalence of spurious goods and the attendant difficulty of procuring the right sort of material. *Dingler's Polytech. Journal, ccvii.* 174.

Use of Silicate of Soda for Cements.—Soluble glass mixed with powdered chalk furnishes a mortar hardening completely in six to eight hours; mixed with antimony sulphide it forms a dark mass, susceptible of a high polish; with iron filings a greyish black very hard mass results, whilst with zinc filings a very hard grey metallic mass is produced, which serves well to cement together zinc work. *Bull. Soc. Chim. Paris, xxi.* 331, *from Dingler's Polytech. Journal, ccxi.* 77.

Cement for Tanks to contain Caustic Liquors.—The tanks may be made of plates of heavy spar, the joints being cemented together with a mixture of

Caoutchouc (finely divided) . .	1 part.
Turpentine oil	2 „
Powdered heavy spar	4 „

Dingler's Pol. Journal, ccx. 399.

Manufacture of Crystal Glass.—CLEMANDOT believes that the black tint sometimes exhibited by flint glass is due to the presence of metallic lead in the red lead used, and hence patents the employment instead of white lead made by the Dutch method; that made by the Clichy process often retains acetic acid, and hence reduction of lead in the crucible is rendered probable. *Bull. Soc. Chim. Paris, xxi.* 335.

Manufacture of Ceramic Colours.—PEYRUSSON patents the preparation for ceramic purposes of colours consisting of the neutral metallic salts of the acids contained in colophony (sylvates, pinates, pimarates, &c.); these are dissolved in carbon disulphide or essence, &c., for use.

The following mixture is made:—

Colophony	100 parts.
Alcohol at 95 per cent. . .	300 „
Alcoholic soda	10 „

After standing for several days, the alcohol is distilled off, and the resulting sodium salts of pinic sylvic and pimaric acids, &c., are converted into the corresponding salts of the metal required (*e.g.*, uranium, iron, &c.) by double decomposition; the metallic salts are then dissolved in oil of lavender or other appropriate solvent. *Bull. Soc. Chim. Paris, xxi.* 335.

Photoceramics.—POLOSSE and LEVY patent the following series of processes. The object to be copied is first obtained in relief by the ordinary chromium-gelatin process; from these reliefs, as models, the ceramic specimens are constructed, or metal objects may be prepared to be subsequently enamelled; no details are given on this part of the process. The objects are then enamelled by applying a thin coating of coloured transparent enamel, and furnaced; in this way objects can be copied with the fidelity of photography, and the unalterable shades and tones of enamel.—*Bull. Soc. Chim. Paris, xxi.* 335.

Preparation of Otto of Roses in Turkey.—HOCHSTETTER states that in the neighbourhood of Kisanlick the flowers of full-leaved roses are used, chiefly *Rosa damascena, sempervirens*, and *moschata*. The plants are cultivated after the manner of vines, in many cases along with these. The chief collecting season is in May, when the flowers are only half opened. The green calices, as well as the flowers, are subjected to distillation, which is nowhere performed on a manufacturing scale, but by every single proprietor in his own house. The still is of copper, about 4 ft. deep by 2 to 2½ wide, tinned inside, and provided with a long cooling-worm. Every charge consists of 50 oka water and 10 to 20 oka roses. The distillate is collected in glass flasks of 7 to 8 oka capacity. The first three or four portions of the distillate, consisting chiefly of water with but little oil, are poured back into the still. When the richness in oil of the distillate has so far increased that there is a layer of about half an inch thickness on the surface of the water, the oil is taken off with little spoons. On an average 5,000 lbs. of roses yield 1 lb. of oil. The price varies according to the harvest, from about 2s. 6d. to 5s. per medical (267 medical=1 oka). Oil of roses is very much adulterated, even in the districts where it is produced; geranium oil (imported from Alexandria) is mixed with it. For export it is packed in copper flasks of 5 lbs. capacity, tinned inside, and sewn into flannel bags.—*Polyt. Centralbl.* 1873, 206.

[*Note by Abstractor.*—The determination of the freezing point is usually employed to ascertain the degree of purity of oil of roses, but attention has been called to the fact that frequently alcohol is added to raise the freezing point. The presence of this latter is best ascertained by pouring some of the oil under investigation into a narrow graduated tube filled with hot water; the alcohol is dissolved by the water, the increased bulk of which may be read off on the scale.—R. G.]

Chemical Tobacco.—HERLAND patents the manufacture of mock cigars by the use of tubes containing two plugs saturated one with ammonia, the other with hydrochloric acid!—*Bulletin Soc. Chim. Paris, xxi.* 334.

[The inventor would probably not smoke *two* of his own cigars.]

Destruction of Domestic Insects.—HIRZEL asserts that an aqueous solution of sulphurous acid is most effective for the destruction of bugs and all their kindred. It suffices to drop the solution into the fissures, holes, &c., where those creatures are supposed to hide.—*Polyt. Centralbl.* 1873, 279.

A PROPOSAL FOR THE SOLUTION OF THE SUEZ CANAL QUESTION.

M. DE LESSEPS' proposal of uniting the Red Sea and the Mediterranean, by opening a new way between America and Europe on the one side, and Asia and Australia on the other, is certainly the greatest idea which has ever been realized in connection with commercial and shipping interests; and as the canal has now been open to shipping for the past three years, the present is the time to examine the question, Has this great work achieved its true purpose? and to this end it will be needful to sketch, in a few words, the history of the Canal.

About the year 1856, M. de Lesseps obtained from His Highness Said Pacha, Viceroy of Egypt, a concession, which had for its object the creation of the Suez Canal, and this grant was ratified by the Sublime Porte. The cost of the canal, it was calculated, would be about £8,000,000; and as the private capitalists to whom application was made did not subscribe much more than about half of this sum, the scheme would have fallen through if the rest of the capital had not ultimately been furnished by the Egyptian Government.

But this additional aid was far from sufficient, for it was soon evident that an important sum would yet be required for the excavation of the canal, and the work, on several occasions, was in danger of being broken off for the want of funds. It is certain that the capital would have been lost if at these crises new resources had not constantly been placed at the disposal of the Company by the Egyptian Government; and the result has shown that the canal, which was to cost about £8,000,000, has really absorbed more than three times as much, of which considerably more than one half, at least, was furnished by the Egyptian Government.

Notwithstanding this increase upon the estimates, however, there was no increase in the dimensions fixed by the concession. On the contrary the canal is even now far from attaining to these, and herein a heavy obligation has still to be met by the Company.

These observations upon the inception of the enterprise will suffice. Let us now consider the situation of the canal since it was opened for shipping.

The calculations made by the Company show that it is necessary that the receipts should constantly reach £640,000 a year, in order to cover the costs of the administration and maintenance of the canal, to pay interest on, and to repay, the loans issued by the Company. Up to the present time the largest amount of traffic through the canal has been about 1,300,000 tons net in a year, and the legal tax being ten francs on the net ton, the product of this tax would be about £520,000. Add to this the receipts from pilotage, towing, &c., say £80,000, and it will be seen that the most that can be raised annually is £600,000, a sum which is insufficient to cover the expenses, to say nothing of meeting a dividend for the shareholders.

To increase their receipts, the Company, on its own authority, created a new type of ton, on which it has, since the 1st July, 1873, rated ships passing through the canal. By this means they procured an increase of nearly 43 per cent. on the legal tax; and it is by such means that the enterprise, which by its original toll could only result in loss, has been able to exist until now. Strong opposition to this illegal proceeding of the Company was manifested, and the question was subsequently taken before the French tribunals, whose competence, however, was contested by M. de Lesseps.

Later on, by the express request of M. de Lesseps, the question was brought before the Sublime Porte, whose sovereign power was invoked to solve it. And he further demanding that the interpretation should rest with this power, declared himself beforehand ready to submit to its decision.

It was no question of judging anew the suit begun by the Messageries Impériales, but simply one of fixing irrevocably the scope and bearing of certain terms in the concession.

In summoning the delegates of the various powers to Constantinople, the Porte could have had no other object than that of having under its eye an International Commission, composed of special and entirely competent men, whose opinions would enlighten their own views, and would serve as a foundation for their decision.

Upon the strength of the unanimous opinions resulting from the debates and the examination of the said Commission, the Sublime Porte availed himself of the rights and powers conferred upon him by M. de Lesseps, and decided that the tax to be levied should be 10 francs for each net ton of 100 cubic feet.

This decision once laid down, the Sublime Porte, on considering the advice given by the Commission upon the financial condition, felt that side by side with the question of strict law, there was one of equity, in virtue of which they might authorize the Company to levy a temporary surtax of 3 francs per net ton, until the traffic had attained a maximum of 2,000,000 tons, and that this tax should be afterwards diminished and completely abolished, when the traffic had reached 2,600,000 tons, and further, the Sublime Porte accorded to the Company a period of three months, during which to decide, either to carry out strictly the terms of the concession, or to modify the plan of levying the tax on the new and equitable basis offered. This generous offer was at first rejected by M. de Lesseps, who declared that he would rather return to the old legal tax of 10 francs than accept the surtax offered by the Sublime Porte, but in acting thus, he had of course no other intention but that of increasing the pilotage and towing dues, and thus to recoup in an indirect manner that which he had not been able to raise by means of this increase of the tax by about 45 per cent. based on the new type of ton. This, however, was as inadmissible as was the unique and entirely exceptional view with respect to the tonnage.

The maximum tax on pilotage, towing, &c. that could legally be raised by the Company is naturally that which is strictly necessary to cover the expenses of their special and altogether secondary services, for it has never occurred to any one that these taxes should become a source of profit, and the best proof of this is that when in the prospectus of the Company, there was expressed a hope of being able to pay the shareholders an interest of about 15 per cent., this hope was based simply on the receipts which were eventually to be derived from the special tax of 10 francs on shipping, said to be simply for covering the charges of maintenance, interest on capital, &c.

The stipulation that the maximum tax on shipping should not exceed 10 francs, would have had no *raison d'être*, if by any means the Company could, to suit its own interest and convenience, arbitrarily impose any other tax.

As the piloting, towing, and harbour dues are at present higher than these special services require, we are justified in referring to the concession, and in demanding a modification of them, but this modification would be in an inverse sense to that demanded by the Company, for it would be necessary to reduce and not to increase them.

Upon steps being taken by the Khedive to carry out the decision of the Porte, M. de Lesseps declared himself ready to accept temporarily the surtax proposed, but under reserve of his protest and the rights of the shareholders.

As the proposal made to the Company was made with the purpose of terminating once for all the difficulties which the subject of the tax might subsequently produce, it required a distinct and categorical acceptation—any acceptation under reserve or protest ought to have been considered as a refusal, and consequently the other alternative of the decision of the Porte—that is, the strict application of the tax of 10 francs per net ton—should have been enforced.

If the Porte and the Khedive did not think it their duty to enforce this, it is the best proof of their moderation that could be required. They certainly have the power, while M. de Lesseps has not withdrawn his protest, to command that the Company shall not levy more than the legal tax of 10 francs. Thus, at present, the Suez Canal question is by no means settled.

From what we have just said with reference to the early management of the Canal it is evident that the Company has no reason whatever to complain that aid and protection have been wanting to them; for the capital which they pretend to have risked has been saved for them more than once. Had the Company been abandoned to its own resources, it would most certainly have succumbed long since, and the capital of the shareholders would have been now lost—buried in the sands of the Egyptian deserts. Certainly a private company never was so well protected!

M. de Lesseps pretends that the Sublime Porte has violated the conditions stipulated in the concession. It is true that, in fact and legally, the concession has been and is even now violated, but it is assuredly in favour of the Company that the violation exists; for after the Sublime Porte had formally decided, on the unanimous advice of all the powers consulted, that the Company had only the right to levy a tax of 10 francs on each ton net, it agreed, at the same time, in accordance with these powers, and having regard to the financial difficulties of the Company, to authorize it to levy a surtax of 3 francs per ton, forgetting when so doing the rights and interests of shipping and commerce, for whose benefit the canal was expressly created, and the original tax of 10 francs fixed.

This augmentation of the tax is therefore diametrically opposed to the interests of commerce and shipping, and is contrary to the purpose which the canal was constructed to achieve, and of which it is necessary above all not to lose sight. The Company had made erroneous calculations from a financial point of view; but to maintain that the consequences of that error should fall upon commerce and shipping would be an utterly untenable position. If, then, the Company cannot exist except under new conditions, which are opposed to the interests of commerce and shipping, how can the question of the canal be solved? is the problem which we are seeking to elucidate.

The Company obviously *can* refuse every proposal offered to them; but in refusing an advantageous and equitable proposal, it not only refuses to accept all subsequent aid, but it assumes by so doing its obligation to fulfil in their integrity the conditions of the concession, which are to levy only 10 francs per net ton, and to enlarge the canal to its necessary and stipulated dimensions.

In obtaining the surtax of 3 francs per ton net the situation of the Company is already considerably ameliorated. Thanks to the aid of the Sublime Porte and the other powers it can now pay nearly 1 per cent. on the capital, while previously it could not cover its expenses. But there is a vast difference between a work covering its expenses and being a lucrative enterprise.

The Company relies on the future, hoping to be able to augment its resources by a great increase of traffic. But here it appears to forget that it is simply the heavy tax which opposes the increase and development of the traffic, and that the only possible means of producing a large increase in shipping going through the canal is that of reducing the tolls.

In a word, it is by levying light taxes that common kinds of merchandise, as well as the superior kinds, may be conveyed through the canal; and it is thus that this grand work will achieve its true end, and become the principal route for the great commerce of the world. It is actually found that for the commerce of Australia and America, the voyage round the Cape is most advantageous, owing to the heavy dues on the Suez Canal route.

It will be easy for us to show by the tables of the Company themselves, how very doubtful it is that they will ever see the traffic increased in any great proportion while their hopes of revenue are based on heavy taxation. The figures compared below show the traffic since 1871 :—

1871, net tonnage	761,000.
1872 „	1,160,000.
1873 „	1,380,000.

Comparison of the first three months of 1873 with the corresponding months of 1874 :—

	1873.	1874.
January . .	173,000 tons. . .	200,000 tons.
February . .	160,000 „ . .	181,000 „
March . .	202,493 „ . .	229,000 „

From a comparison of these figures it is seen that the increase of the traffic upon the year 1872 was 52 per cent. more than that of the preceding year, while in 1873 this increase was 19 per cent. and 13 per cent. only during the first three months of 1874.

Supposing that in the course of twenty-six years the traffic increased at the rate of 50,000 tons yearly, it would at the end of that time have reached to an annual tonnage of 2,600,000 tons.

The produce of the special tax on shipping, and that on piloting, &c., would be in the twenty-seventh year about £1,040,000 to £1,080,000, and when we deduct from this the £640,000, which we estimate as necessary for payment of interest, refunding the loans, the maintenance of the canal, then is left about £400,000 or £440,000, equivalent to an interest of say 6 per cent.

But what guarantee have we that the traffic in the course of the twenty-sixth year will have attained the figure of 2,600,000 tons? Absolutely none!

Besides, we have not taken into consideration the sums required for the repairs of the canal and its necessary enlargement; all this, however, might be adjourned perhaps until the

end of the twenty-six years, when the Company would be paying an interest of about 6 per cent.

If, however, counting from the present time even, the Company could be indemnified on the basis of an interest of about 5 per cent. on their capital, such a transaction would assuredly be very advantageous for the shareholders.

Let us see how such a transaction would be possible. The cost of the canal, says the Company, amounts to about £12,800,000, independently of the sacrifices made by the Egyptian Government, and may be divided as follows :—

Shares belonging to private individuals . . .	4,480,000
„ „ His Highness the Khedive .	3,520,000
Loan of 1867-8, with mortgage on the canal . .	3,999,996
„ 1871, to be reimbursed from what the Khedive's loan (the £3,520,000 worth of stock) may produce in twenty-five years[1]	800,000
	12,799,996

With a tax of 13 francs per net ton on all ships without exception,[2] the receipts from shipping, pilotage, &c. would be at the present day about £720,000, and supposing it possible to reduce the expenses of the service and maintenance of the canal to £120,000, there would remain an overplus of £600,000, the interest on the *amortissement* of the loans taken up by the Canal Company, amounting to nearly 9 per cent., and that to be allowed to the shareholders to nearly 3 per cent. plus 1 per cent. for the *amortissement* it will be necessary to estimate an average of 8 per cent. as the interest to be paid on the sums to be reimbursed. Upon this basis of 8 per cent. the net annual return of £600,000 would correspond to a capital of about £7,400,000 ; this is then the quota which henceforth would have to be borne by shipping.

The present tax of 13 francs would only be necessary during the first year, for with the increase of the traffic and by the application of a portion of the revenue to the *amortissement* of the capital, the tax would year by year be considerably diminished. Admitting only that in the course of twenty-six years the traffic with a tax always decreasing was increased to the extent of 70,000 tons yearly, it would consequently have attained by the twenty-seventh year the figure of about 3,200,000 tons, and the tax could then be reduced to nearly 4 francs per ton—the other quota of the cost of the canal would then be £6,400,000. But here it must not be forgotten that in valuing the canal at £12,800,000 the amount of £80,000, which is comprised therein represents the interest on £3,520,000 worth of stock belonging to the Khedive for a term of twenty-five years.

The reimbursement of this capital of £3,520,000 need not therefore be commenced until the expiry of the twenty-five years.

The sum to be found immediately, and which cannot be borne by shipping will not therefore be, £5,400,000, but this sum less £3,520,000, say £1,880,000.

The continued diminution in the amount of the tax would greatly develop the traffic of the canal, and it is reasonable to believe that the re-imbursement of part of the capital of £5,400,000 might be borne by shipping owing to the increase of traffic produced even at the commencement of the twenty-sixth year.

We have not here taken into account the expenses and the indemnities to be paid for the extinction of some works when the canal shall cease to exist, nor the capital necessary for the enlargement of the canal, for which it would be necessary to create a reserve fund, and there is no doubt that a sum of less than £1,200,000 would suffice for this reserve.

In the earlier years the expenses for enlarging the canal, &c. would surpass by a good deal the interest of the capital of £1,200,000. But nothing would be more easy, with the guarantee of this reserve fund, than to make a loan to meet the exceptional and isolated expenses of these first years, and later, the interest of the reserve fund would serve not only to repay the loan, but further, to contribute to the rapid *amortissement* of the £7,600,000 which would have to be borne by shipping.

In a word, in order to reduce the tax in the course of time to nearly 4 francs, it would be necessary to fund a sum of £3,080,000, say in round figures £3,000,000. The rest, that is the £7,600,000, might be borne directly by commerce and shipping, if the principle of a continuously decreasing tax were adopted.

[1] H. H. The Khedive has given up the interest on his stock for a term of twenty-five years in favour of the Company, as an indemnity for the redemption of certain privileges which the Egyptian government had gratuitously ceded to the Company.

[2] On ships of war, troopships, and ships carrying ballast, the toll is 10 francs per net ton only.

It would be for the Egyptian Government to transact the business of the redemption of the canal with the Company, and to furnish it with a sufficient guarantee for the repayment of the interest, which would be very easy both by the means of the revenues of the canal as well as by the reserve fund of £1,200,000, and the £3,520,000 worth of stock belonging to the Khedive.

The Egyptian Government should then give a guarantee to the different States on entering into an Convention with them similar to those concluded not long since with Denmark for the redemption of the Tolls of the Sound, with Belgium for the Scheldt, with Hanover for the Stade.

The principles of this Convention would naturally be—

1. The establishment of the annual reduction of the tax, which the Egyptian Government would allow, imposed on shipping using the canal.

2. The payment by the Powers of the sum of £3,000,000 to Egypt.

3. The establishment of the conditions of the re-imbursement after the twenty-five years of the total sum of £3,520,000 worth of stock belonging to the Khedive, or a part of that sum, the amount to be reimbursed depending naturally on the development of the traffic and on the sum which could then be borne by shipping.

As regards the administration of the canal, it should belong entirely to Egypt ; any foreign co-operation would only give rise to jealousy and complications. There is no reason for the belief that the canal which has been well managed by a private Company could not be equally well managed by the Egyptian Government, which naturally would retain the present *personnel* in its service. Egypt possesses administrations—railways, for example, which are conducted in a satisfactory manner, and which are more complicated and difficult and require more surveillance than the canal would do. If we remember that the tolls on shipping using the Belt were redeemed for a sum of about £4,000,000 and that the traffic through it is small compared with that which will pass through the Suez Canal, destined as it is to be the principal means of communication between Europe and America on the one side and Europe and Asia on the other, we cannot certainly consider £3,000,000 too much for the purpose of reducing the present tax to 4 francs.

As all taxes imposed on shipping only increase the charges of the freight, which, after all, fall upon merchandise, the tax therefore weighs actually upon the consumer and the producer.

European and American goods are articles of the greatest necessity in Asia and Australia, as the articles from these last countries are in the former. Thus the Swiss consumers as well as the English, profit by the reduction in the price of goods from Australia and America coming through the canal, and the reduction of the tolls is equally useful to both. It is clear therefore that it is a matter of importance that each country should facilitate as much as possible the accessibility of the canal to shipping, in order that they may obtain goods at lower prices ; and the importance of this to each country is in exact proportion to its general commerce, independently of its direct relations with the Suez Canal.

It is, therefore, the general commerce of each country, which should be the basis of its contribution to the redemption of the tolls.

In ceasing to belong to a private company, and in coming under the control of the Egyptian Government, the canal would cease to be the object of jealousy to different nations, and the sources of grave diplomatic complications between them.

We have recently seen a grave conflict arising from the existing condition, and there is no guarantee that new difficulties bringing fresh complications with them may not arise in the future? We sometimes hear the fear expressed that the canal may be bought by an English company ; to those who have this unfounded fear, we may say that the best way in which to avoid its realization will be to make the canal entirely Egyptian. At present, while it belongs to a private company, nothing would be easier than to buy shares in France to send to London, and thus to make the canal as much English as it now is French.

In becoming exclusively Egyptian property, all competition on the subject of nationality would cease at once, and the Canal would naturally be regulated in the same way as the other straits alluded to—by the well known laws of nations ; to wit, that every merchant ship should have the right to pass through it at any time conformably to the text of the concession.

As for ships of war, their passage would also be subject to the same rules which govern other straits, viz. that if in time of peace the canal is free for passage from one sea to another, it is closed in time of war to ships of an enemy's country. If the passage were made by them under these circumstances, it would be by force resulting from the state of war.

It would certainly be as useless to wish to create a new law of

nations for the seas of the globe as to endeavour to invent a new law for the ships passing through the Suez Canal. In one word, the rules of the canal should be in every way the same as those governing other seas and straits.

Concerning the pecuniary advantages to the Company, we have already pointed out that they would be very great.

The shareholders, at one stroke, would have the interest on their shares increased from 1 to 5 per cent., an interest which, under the present system, the enterprise would not yield for a great number of years.

As to Egypt, not the least satisfactory part of the arrangement for her would be that she would not be involved continually in new political complications, such as when quite recently an armed force had to be sent to carry out an imperial edict. Besides, the canal would, in course of time, become beneficial to Egypt from a financial point of view; for when once the traffic has become considerably augmented, a fixed tax of about 3 francs could be established and easily borne by shipping, and this would be more than enough to cover the expenses of maintenance, and would leave a surplus for the Egyptian Government.

Finally, the canal is at present frequented for the most part by ships bearing the English flag, while those of other countries —France, Italy, Austria, &c.—are only represented by the ships of their postal companies.

Are these the only advantages that the great cities of the Mediterranean and the Adriatic—such as Marseilles, Genoa, Leghorn, Naples, Venice, Trieste, Barcelona, &c.—have a right to expect from this great enterprise which at its inception promised so much? Certainly not. And we are pleased to think that sooner or later the natural and powerful course of circumstances will bring about, little by little, the realization of those numerous promises which were made at the creation of this admirable and useful work.

As to the pretence of the Company to wish to bind its own interests to those of France, it is necessary to observe that France, while protecting this great work, has never done so in the wish at any cost to procure a benefit for an industrial company. It gave its protection for a much higher purpose.

When once so favourable an opportunity is offered to the shareholders of the canal, who are now unable to fulfil their obligations to it, France more than any other government would naturally protect any scheme which had for its object the advancement of the public interest; and this alone was the purpose of the Suez Canal.

We live in an age when any sum needed to cover the expenses of a war is easily procurable, and it remains to be seen whether the powers of the world would be so united in a cause of such general and incontestable utility as to contribute a sum so comparatively small as £3,000,000. Not only is this matter opportune to the moment, but all delays are contrary to the purpose in view of which the great work of the Suez Canal was undertaken.

Below is a comparative statement of the proportion which would have to be contributed by the various states of the world for the reduction of the Suez Canal tolls, based on the plan of a total contribution of £3,000,000 :—

Countries.	Approximate Imports and Exports.	Proportion to be paid.
	£	£
Germany	183,000,000	239,600
Austria and Hungary	102,000,000	133,800
Belgium	86,000,000	111,800
China	45,000,000	58,600
Denmark	7,000,000	9,000
Spain and its Asiatic Possessions	20,000,000	25,600
The United States of America	34,000,000	44,600
France with its Possessions	227,000,000	297,000
England with its Possessions	264,000,000	345,000
Greece	830,000,000	1,086,000
Italy	5,000,000	6,400
Japan	82,000,000	107,600
Morocco	20,000,000	25,700
Holland	1,500,000	1,800
Persia	104,000,000	136,600
Portugal and its Possessions	4,000,000	5,000
Russia	10,000,000	12,800
Sweden and Norway	95,000,000	124,300
Siam	28,000,000	36,400
Switzerland	2,500,000	3,000
Turkey with Roumania, Servia, Tunis, Tripolis, and Arabia	110,000,000	143,400
	2,295,000,000	3,000,000

The proportion to be paid by each country for the redemption of the tolls should therefore be in relation to its general commerce. But it is only just to take into consideration also the extent to which the canal has shortened the distances between the various countries concerned. For example, North America should contribute a less proportion than the countries of the Mediterranean.

The annexed table shows the distance between Bombay and the principal countries of Europe, both by way of the Cape and of the Canal :—

Ports of Europe and America.	Distance from Bombay.		Difference.
	By the Suez Canal.	By the Cape.	
	Leagues.	*Leagues.*	*Leagues.*
Constantinople	1,800	6,100	4,300
Malta	2,062	5,800	3,738
Trieste	2,340	5,900	3,560
Marseilles	2,374	5,650	3,276
Cadiz	2,224	5,200	2,976
Lisbon	2,500	5,350	2,850
Bordeaux	2,800	5,660	2,860
Havre	2,824	5,800	2,976
London	3,100	5,950	2,850
Liverpool	3,040	5,900	2,860
Amsterdam	3,100	5,940	2,840
St. Petersburgh	3,700	6,550	2,850
New York	3,761	6,200	2,439
New Orleans	3,727	6,450	2,723

SOLDERING IRON AND STEEL.—As it is often necessary in manufacturing operations of different kinds to unite iron and steel by other means than welding, the following practical hints, which we translate from "Wiederhold's Gewerbeblätter," will be found worth remembering :—

"For large and heavy pieces of iron and steel, copper or brass is used. The surfaces to be united are first filed off, in order that they may be clean; then they are bound together with steel, and upon the joint a thin strip of sheet copper or brass is laid, or, if necessary fastened to it with a wire. The part to be soldered is now covered with a paste of clay, free from sand, to the thickness of one inch, the coating being applied to the width of a hand on each side of the piece. It is then laid near a fire, so that the clay may dry slowly. The part to be soldered is then held before the blast, and heated to a white heat, whereby the clay vitrifies. If iron is soldered to iron, the piece must be cooled off in water. In soldering steel to steel, however, the piece is allowed to cool slowly. The semi-vitrified clay is then knocked off, and the surface is cleaned in a proper manner. By following the hints given, it will be found that a durable and clean soldering is obtained. If brass instead of copper is used, it is not necessary to heat so strongly; the former recommends itself, therefore, for steel. Articles of iron and steel of medium size are best united with hard or soft brass solder. In both cases the seams are cleanly filed and spread over with the solder and borax, when the soldering seam is heated. Hard brass solder is prepared by melting in a crucible eight parts of brass, and adding one part of previously heated zinc. The crucible is then covered and exposed to a glowing heat for a few minutes, then emptied into a pail with cold water, the water being strongly agitated with a broom. Thus the metal is obtained in small grains or granules. Soft brass solder is obtained by melting together six parts of brass, one of zinc, and one of tin. The granulation is carried out as indicated above. Small articles are best soldered with hard silver solder or soft solder. The former is obtained by alloying equal parts or fine silver and soft brass. In fusing, the mass is covered with borax, and, when cold, the metal is beaten out to a thin sheet, of which a sufficiently large and previously annealed piece is placed with borax upon the seams to be united and heated. Soft silver solder differs from hard silver solder only in that the former contains one-sixteenth of tin, which is added to it during fusion. Very fine articles of iron and steel are soldered with gold, viz., either with pure gold or hard gold solder. The latter can be obtained by fusion of one part gold, two parts silver, and three copper. Fine steel wire can also be soldered with tin, but the work is not very durable. Hard and soft brass solder are used for uniting copper and brass to iron and steel, silver solder for silver, hard gold solder for gold."

BEDSTEAD IN THE RENAISSANCE STYLE. BY P. MAZAROZ-RIBALIER.

ON THE STRENGTH, ELASTICITY, DUCTILITY, AND RESILIENCE OF MATERIALS OF MACHINE CONSTRUCTION;

AND ON VARIOUS HITHERTO UNOBSERVED PHENOMENA, NOTICED DURING EXPERIMENTAL RESEARCHES WITH A NEW TESTING MACHINE, FITTED WITH AN AUTOGRAPHIC REGISTRY.[1]

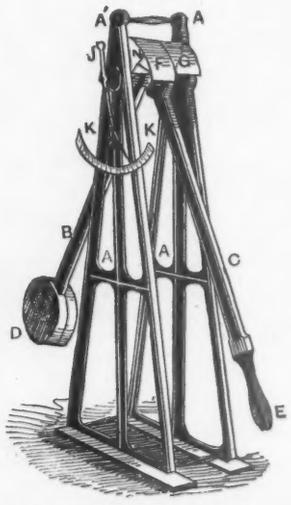
SECTION I.

1. *INTRODUCTORY.*—Some months ago, while engaged with the advanced classes of the Stevens Institute of Technology, in experimental investigations of the resistance of materials, it was found that co-efficients were given, by various authorities, which neither accorded fully with each other, nor with those then obtained.

The desirability of determining how far these differences were due to errors of observation, and how far to variation in the quality of the materials examined, induced the writer to design several machines for the purpose of conducting with them a more extended and exact series of experiments. The machine for measuring torsional resistance was furnished with an automatic registry, recording a diagram which is a reliable and exact representation of all circumstances attending the distortion and fracture of the specimen. No system of personal observation could probably be devised which could yield results either as reliable or as precise as such a system of autographic registry; and as no method previously in use had given simultaneously, and at every instant during the test, the intensity of the distorting force and the magnitude of the coincident distortion, it was anticipated that the new method of investigation might be fruitful of new and, possibly, important results. This expectation, as will be seen, has been more than realized.

2. *Description of the Apparatus.*—The machine, as planned by the writer, and as built in the instrument-maker's workshop at the Stevens Institute, is shown in fig. 1. This form is that

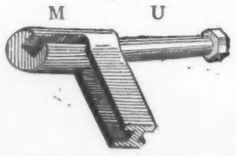
Fig. 1.



with which the investigations to be described were made. Since its construction in 1872, however, some changes and improvements have been made in the design to adapt it to general work, and new designs have been made for special kinds of work, as for wire mills, railroad shops, and bridge building.

Two strong wrenches, C E, B D, are carried by the frames A A, A′ A′, and depend from axes which are both in the same line, but are not connected with each other. The arm, B, of one of these wrenches carries a weight, D, at its lower end. The other arm, C, is designed to be moved by hand in the smaller machines, and by a gear and pinion, or a worm gear in larger forms of the apparatus. The heads of the wrenches are made as shown in fig. 2, the recess, M, being fitted to take the head,

Fig. 2.



on the end of the test pieces, which is usually given the form shown in fig. 4.

A guide curve, F, of such form that its ordinates are precisely

Fig. 3.

proportional to the torsional moments exerted by the weighted arm B D, while moving up an arc to which the corresponding abscissas of the curve are proportional, is secured to the frame

Fig. 4.

A A′. The pencil-holder, J, is carried on this arm, B D, and as the latter is forced out of the vertical position, the pencil is pushed forward by the guide curve, its movement being thus made proportionate to the force which, transmitted through the test piece, produces deflection of the weighted arm. This guide line is a curve of sines. The other arm, C E, carries the cylinder, G, upon which the paper receiving the record is clamped, and the pencil, J, makes its mark on the table thus provided. This table having a motion relatively to the pencil, which is precisely the angular relative motion of the two extremities of the tested specimen; the curve described upon the paper is always of such form that the ordinate of any point measures the amount of the distorting force at a certain instant, while its abscissa measures the distortion produced at the same instant. The maximum hand, J, is sometimes useful as a check upon the record of maximum resistance.

The convenience of operation, the small cost,[1] and the portability of the machine are hardly less important to the engineer than the accuracy and the extraordinary extent of information obtainable by it.

3. *Method of Operation.*—The test-piece having been given the shape and size which are found best suited for the purposes of the experiment and to the capacity of the machine, it is placed in the jaws of the two wrenches, each of which takes one of its squared ends, and a force being applied to the handle, E, the strain thrown upon the specimen is transmitted through it to the weighted arm, B D, causing it to swing about its axis until the weight exerts a moment of resistance, which equilibrates the applied force. As the magnitude of the distorting force changes, the position of the weight simultaneously changes, and the pencil indicates, at each instant, the value of the stress upon the test-piece. As the piece yields under strains of increasing amount also, the pencil is carried in the direction of the circumference of the cylinder on which its record is made, and to a distance which is proportional to the amount of distortion, *i.e.* to the "total angle of torsion." As the applied force increases, the specimen yields, and finally rupture occurring, the pencil returns to the base line, at a distance from the starting point which measures the angle through which the test-piece yielded before its fracture became complete.

4. *Interpretation of the Diagrams.*—It has been shown that the vertical scale of the diagrams produced is a scale of torsional moments, and that the horizontal scale is one of total angles of torsion. Since the resistance to shearing, in a homogeneous material, varies with the resistance to longitudinal stress, it follows that the vertical scale is also, for such materials, a scale of direct resistance, and that, with approximately homogeneous substances, this scale is approximately accurate, where, as here, all specimens compared are of the same dimensions.

[1] This paper was read on Feb. 14, by Professor R. H. Thurston, Member of the American Society of Civil Engineers, and is here reprinted from "Van Nostrand's Engineering Magazine."

[1] Machines of the size of that used in these experiments, but of improved design, are made at the Stevens Institute, at prices as low as £30.

Since the elasticity of the material is measured by the ratio of the distorting force to the degree of temporary distortion produced, the diagrams obtained will exhibit the elastic properties of the material, as well as measure its ductility and its resilience.

Referring to the diagrams shown in the accompanying plates, it will be noticed that the first portion of the line is a curve of small radius, convex toward the axis of abscissas, and that the line then rises at a slight inclination from the vertical, but becoming very nearly straight, until, at a point some distance above the origin, it takes a reversed curvature. The first portion of the line is probably formed by the yielding of the loosely fitted packing pieces securing the heads of the specimen, and after they have taken a bearing, by the early yielding, in some materials, of particles already overstrained. When a firm hold is obtained, the line becomes sometimes nearly straight, and the amount of distortion is seen to be approximately proportional to the distorting force, illustrating Hooke's law, "*Ut tensio sic vis.*"

After a degree of distortion which is determined by the specific character of each piece, the line becomes curved, the change of form having a rate of increase which varies more rapidly than the applied force. When this change commences, it seems probable that the molecules, which, up to that point, retain generally their original distribution, while varying their relative distances, begin to change their positions with respect to each other, moving upon each other in a manner similar, probably, to that action described by M. Tresca, and called the "Flow of Solids,"[1] and to which attention has already been called by Prof. J. Thompson.[2]

It is this point, at which the line commences to become concave toward the base, that is considered to mark the "limit of elasticity." It will be noticed that it is well defined in experiments upon woods, is less marked, but still well defined in the "fibrous" irons and the less homogeneous specimens of other metals, and becomes quite indeterminable with the most homogeneous materials, as with the best qualities of well worked cast-steel. This point does not indicate the first "set," since, as will be hereafter seen, a set is found to occur, either temporary or permanent, and usually partly temporary and partly permanent, with every degree of distortion, however small. It is at this "elastic limit" that the sets begin to become considerable in amount and almost wholly permanent.

The inclination of the straight portion of the line from the vertical measures the stiffness of the specimen, the quantity $\cot.\ \theta = \frac{1}{\tan.\ \theta}$ being the ratio of the distorting force to the amount of distortion up to the "limit of elasticity." As it would seem from the results of experiment as well as of deduction, that this rigidity is very closely if not precisely proportional to the hardness in homogeneous substances, this quantity $\cot.\ \theta$ may be taken for practical purposes as a measure of the hardness of the metals, as well as of their elastic resistance to compression.

After passing the elastic limit, the line becomes more and more nearly parallel to the base line, and then, with the woods invariably and in some cases with the metals, begins to fall rapidly before fracture becomes evident in the specimen. Where the rising portion of the line turns and becomes nearly parallel with the axis of abscissas, the viscosity of the material is such that the outer particles "flow" upon those within, and, while themselves still offering maximum resistance, permit molecules nearer the axis to also resist with approximately maximum force. It seems probable that, with the more ductile substances, nearly all are brought up to a maximum in resistance before fracture occurs, and this circumstance will be seen hereafter to have an important influence in determining the resistance to rupture. The hardest and most brittle materials break, with a snap, before any such flow becomes perceivable, and before the line of the diagram commences to deviate in the slightest degree from the direction taken at the beginning, and before the approach to the elastic limit is indicated. It is evident that the standard formulas for torsional, as well as for other forms of resistance, cannot be perfectly correct, since they do not exhibit this difference in the character of the resistance offered by ductile and by rigid materials.

The elasticity of the material is determined by relaxing the distorting force, at intervals, and allowing the specimen to relieve itself from distortion so far as its elasticity will permit. In such cases, the pencil will be found to have traced a line resembling, in its general form and position, in respect to the coördinates, that forming the initial portion of the diagram, but almost absolutely straight, and more nearly vertical. The degree of inclination of this line indicated the elasticity, precisely as the initial straight line was made to give a measure of the original stiffness of the test piece, the cotangent of the angle made with the vertical, $\cot.\ \phi = \frac{1}{\tan.\ \phi}$ being the ratio of the force required to spring the piece through the range recoverable by elasticity, to the magnitude of that range. The fact to be shown, that this value is always greater than $\cot.\ \phi$, for the same metal, is evidence that more or less permanent set will always occur, and that the original stiffness of the specimen is always modified, whatever the magnitude of the applied force. The form of the line of elastic change indicates also the character of the molecular action producing it.

Finally, the form of the curve after passing the maximum, or after passing the point at which fracture commences, exhibits the method of variation of strength during the process of fracture. This portion is very difficult to obtain, with even approximate accuracy, with any but the toughest and most ductile materials. This terminal portion of the diagram would be, theoretically, a cubic parabola, the loss of resisting power varying with the progressive rupture of concentric layers, and the remaining unbroken cylindrical portion becoming smaller and smaller until resistance vanishes with the fracture of the axial line. In some cases, the curves obtained from ductile metals exhibit this parabolic line very distinctly. In all hard materials, the jar produced by the sudden rupture of surface particles is sufficient to separate those within, and the terminal line is straight and vertical.

The homogeneity of the material tested is frequently hardly less important than its strength, and it is very desirable to obtain evidence which may enable the experimenter to determine the value of tests of samples as indicative of the character of the lot from which the specimens may have been taken. If the specimens are found to be perfectly homogeneous, it may be assumed with confidence that they represent accurately the whole lot. If the samples are irregular in structure and in strength, no reliable judgment of the value of the lot can be based upon their character, and there can be no assurance that, among the pieces accepted, there may not be untrustworthy material which may possibly be placed just where it is most important to have the best. It is evident that the more homogeneous a material, the more regularly would changes in its resistance take place, and the smoother and more symmetrical would be the diagram. The depression of the line immediately after passing the elastic limit exhibits the greater or less homogeneousness of the material. The fact is illustrated in a striking manner in some of the curves presented, and we thus have—what had never, I believe, been before found—this method of determining homogeneousness.

The resilience of the specimen is measured by the area included within its curve, this being the product of the mean force exerted into the distance through which it acts in producing rupture, *i. e.*, it is proportional to the work done by the test piece in resisting fracture, and represents the value of the material for resisting shock. The area taken within the ordinate of the limit of elasticity, measures the capacity for resisting shock without serious distortion or injurious set.

The ductility of the specimen is deduced from the value of the total angle of torsion, and the measure is the elongation of a line of surface particles, originally parallel to the axis, which line assumes a helical form as the test piece yields, and finally parts at or near the point where the maximum resistance is formed. Its value is given on Plates II. and III. for each 10 deg. of arc. Since, in this case, there is no appreciable reduction of section or change of form in the specimen, this value of elongation is our actual measure of the maximum ductility of the material, and is an even more accurate indication than the area of fractured cross section as usually measured after rupture by tension. It is to be understood that wherever comparisons are here made, without the express statement of other conditions, specimens of the same dimensions are always represented in the diagrams.

5. *Description of Illustrated Diagrams. The Woods.*—Plates I. and II. exhibit sets of curves which illustrate the general characteristics of a large number of materials, the first showing the peculiarities noted during experiments on the woods, and the second giving an interesting comparison of the metals.

The woods experimented upon were the following, the numbers of the respective curves on Plate I. indicating the material here correspondingly marked :—

1. White pine (*Pinus Strobus*).
2. Southern pine (*Pinus Australis*), sapwood.
3. Southern pine, heartwood.
4. Black spruce (*Abies nigra*).
5. Ash (*Fraxinus Americanus*).

[1] "L'Ecoulement des Corps Solides." Paris, 1869, 1871.

[2] "Cambridge and Dublin Mathematical Journal," vol. iii., 1848, pp. 252-266.

6. Black walnut (*Juglans nigra*).
7. Red cedar (*Juniperus Virginianus*).
8. Spanish mahogany (*Swietenia Mahogani*).
9. White oak (*Quercus alba*).
10. Hickory (*Carya alba*).
11. Locust (*Robinia Pseudo-acacia*).
12. Chestnut (*Castanea vesca*).

The specimens are all of the forms shown in fig. 3, $3\frac{3}{4}$ in. long, with a diameter of neck of $\frac{7}{8}$ in.

It will be noticed that, in all cases, at the commencement of the line, it rises at a slight inclination from the vertical and almost perfectly straight. This confirmation of Hooke's law, within the limit of elasticity, is best shown in the detached portion *a*, *a*, *a*, of the curve obtained with locust, in which the horizontal scale is somewhat magnified. The distortion is seen to be very precisely proportional to the distorting force, until the law changes at the limit of elasticity.

It will be observed that, in the larger number of cases, the torsional resistance increases with great regularity nearly to the angle of maximum stress, where, suddenly, this rapid rate of increase ceases, and the limit of elastic resistance being passed, resistance diminishes rapidly with further increase of angular movement, until it becomes zero. In the tougher and more dense varieties, this decrease of resistance occurs less slowly, and in some cases only disappears after a large angle of torsion is recorded. In the curves of exceptionally strong and tough woods, in which there is known to exist a great excess of longitudinal over lateral cohesion, as in those of black walnut 6, 6, locust 11, 11, and especially in those of hickory 10, 10, a peculiarity is perceivable which is somewhat remarkable, and which is especially important in a connection to be hereafter referred to at length.

In these instances the resistance is proportional to the amount of torsion, until a maximum is reached; the line then falls as torsion continues, until a minimum is passed, the curve then again rising and passing another maximum before finally commencing an unintermitted descent to the axis of abscissas. Where the difference between longitudinal and lateral cohesion is exceptionally great, the second maximum may, as illustrated, for example, by the line described in recording the test of hickory, have a higher value even than the first. This interesting and previously unanticipated peculiarity was shown, by careful observation, to be due to the sudden yielding of lateral cohesion when the torsional moment reached the value indicated by the first minimum. The fibres being thus loosened from each other, this loose bundle of filaments yielded readily, until, by lateral crowding as they assumed a helical form and enwrapped each other, their slipping upon each other was gradually checked, and resistance again commenced increasing. At the second maximum, yielding again began, in consequence of the breaking of fibres under the longitudinal stress measured by that component of torsional force having a direction parallel with the filaments in their new positions, the exterior surface threads parting first under this tensile stress, and rupture progressing by the yielding of layer after layer, until, the axial line being reached, resistance vanished. In this case rupture seems never to occur by true shearing along one defined transverse plane. This feature of depression in the curve, occurring as described, is therefore the indication of a lack of symmetry in the distribution of resisting forces. It is evident that it may occur either by a difference in the value of cohesive force in the lateral and longitudinal directions, or by the structural defects of a specimen, in which the substance itself may be endowed with cohesion of equal intensity in all directions.

The curves shown in Plate I. exhibit well the relative values of these materials for the various purposes of the engineer.

White pine, 1, 1, 1, is shown by the considerable inclination of the line of stiffness from the vertical, to be soft and deficient in rigidity. The limit of elasticity is quickly reached, and the maximum resistance of the specimen is found at $15\frac{1}{2}$ foot-pounds of moment. Rapidly losing strength after passing the limit of resistance, it is entirely broken off at an angle of 130°. The small area comprised by the diagram proves its deficiency of resistance, and its inability to sustain shock.

Yellow pine, 2, 2, 2, 3, 3, 3, far excels the first in all valuable properties shown by the curve. The sapwood seems, in the specimens tested, equally stiff with the heart, but it reaches the elastic limit sooner. The general form of the diagram is the same in both, and is characteristically different from that of the white pine. It evidently has great value wherever rigidity, strength, toughness, and resilience are desired in combination with lightness, the latter most important quality, together with their cheapness, aiding the qualities here shown in determining the application of these woods so extensively for general purposes. It should be noted that, since all comparisons of strength are based on measures of volume, a comparison of densities should usually be obtained to assist the judgment in making a choice from among materials of which tests have been made.

Spruce, 4, 4, 4, while possessing far less stiffness than even white pine, excels it somewhat in strength, passing its maximum at 18 foot-pounds, and submitting to a torsion of nearly 200°. It is proven to possess proportionally greater resilience also. It is, however, far inferior to the yellow pine in every respect.

Ash, 5, 5, 5, is more deficient in strength and toughness than is generally supposed, and rapidly loses its power of resistance after passing the maximum, which point is found at about $27\frac{1}{2}$ foot-pounds. These specimens may have been of exceptionally poor quality, or, possibly, were over-seasoned.

Black walnut, 6, 6, 6, is remarkably stiff, strong, and resilient, its diagram resembling somewhat that of oak in general form and dimensions. The maximum of resistance reaches 35 foot-pounds, and the most ductile specimen was only broken off after yielding through an arc of 220°. Its stiffness is shown by the fact that it required a moment of 25 foot-pounds to spring it 10°, yellow pine requiring but 22 foot-pounds, and spruce but 8 to give them the same amount of distortion.

Red cedar, 7, 7, 7, is very stiff, but is brittle and deficient in strength, breaking off at 92°, and having a maximum power of resistance of but $20\frac{1}{2}$ foot-pounds. It is, however, one of the stiffest of the woods, its specimen requiring 20 foot-pounds of torsional moment to produce a total angle of torsion of but 5°.

Spanish mahogany, 8, 8, 8, is both strong and stiff, bearing a stress of 44 foot-pounds, and requiring 32 to produce a torsion of 10°.

White oak, 9, 9, 9, exhibits less strength than either good mahogany, locust, or hickory, but it is exceedingly tough and resilient. Passing the maximum at an angle of 15°, under a torsional stress of $35\frac{1}{2}$ foot-pounds, it retains its power of resistance nearly unimpaired up to about 70°, and then slowly yields until it suddenly gives way, after passing the angle of 250°, under a strain due to 9 foot-pounds, and breaks off completely at 253°. This strength, toughness, and endurance, under strains due to impact, may be attributed to its considerable lateral cohesion, and to the interlacing of its tenacious fibres, which gives this wood its "cross" grain.

Hickory, 10, 10, 10, has the highest maximum found during these experiments, the second of the pair of maxima already referred to, being considerably above the maximum of locust even. This specimen exhibits well the well-known valuable properties of the material, requiring 45 foot-pounds to twist it 10°, reaching a limit of elasticity at 54 foot-pounds and 13°, and having a maximum resisting moment of $59\frac{1}{2}$ foot-pounds. When it finally yields, it does so quite rapidly, breaking off at 145°.

Locust, 11, 11, 11, gives an excellent diagram. It is the stiffest of all, yielding but 10° at its maximum of 55 foot-pounds, and one piece, which was unusually hard and compact, requiring 48 foot-pounds to distort it 4°, and reaching a maximum angle of torsion of nearly 190°.

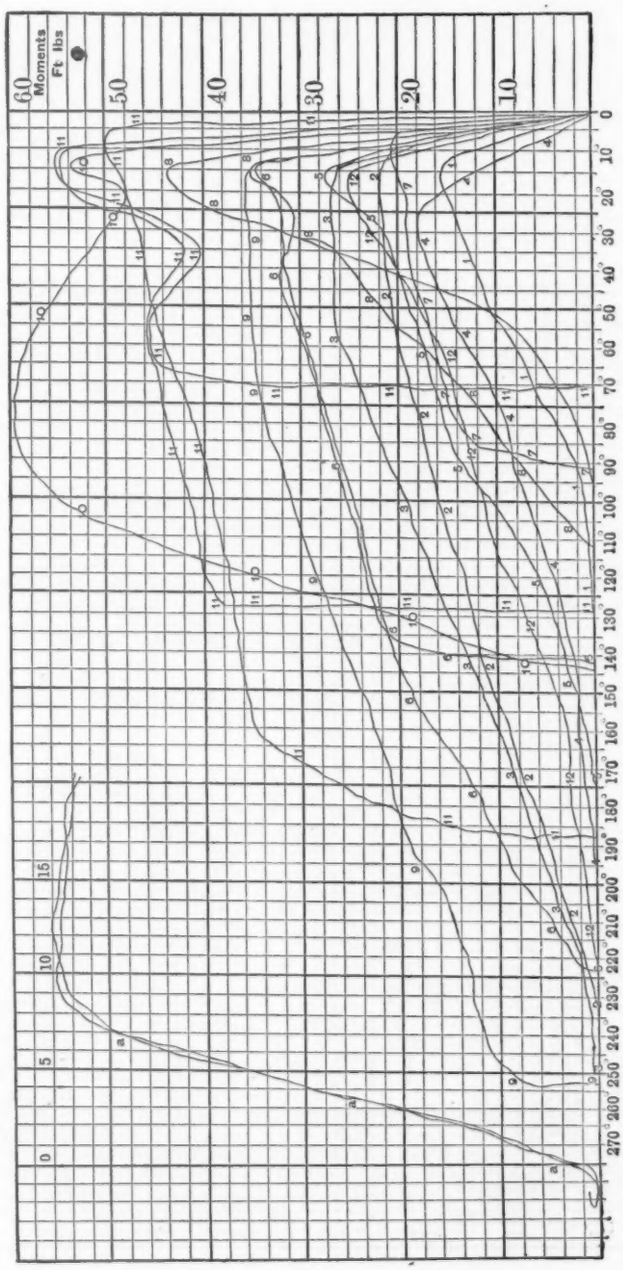
It was noticed, during this series of experiments, that different specimens of the same species of wood usually exhibited very nearly equal strength and rigidity, and that marked differences were only occasionally noted in elasticity and resilience.

6. *The Metals, and Curves produced by them.*—Plate II. exhibits a series of curves which illustrate well the general characteristics and the peculiarities of representative specimens of the principal varieties of useful metals. In some cases two specimens have been chosen for illustration, of which one presents the average quality, while the other is the best and most characteristic of its class.

The diagrams obtained by testing metals are quite different in general character from those registered in experiments on the woods, yet there are some points of resemblance which it will be instructive to notice, since these similar characteristics indicate similar properties of the two materials, and a comparison aids greatly in the interpretation of the diagrams. The woods have a structure which differs, in a distinguishing degree, both in the distribution of the substance and in the action of those molecular forces capable of resisting rupture, from that of the metals, the latter being far more homogeneous, in both respects, than the former. Wood consists of an aggregation of strong fibres, lying parallel, or approximately so, and held together often by a comparatively feeble force of lateral cohesion. The latter force being, as often happens, destroyed, the mass becomes a collection of loose threads having the general character of a rope or cord, with slight or no twist. The metals, on the other hand, are naturally homogeneous, both in structure and in the distribution and intensity of the molecular forces. Well-worked and thoroughly annealed cast-steel, as an example is equally strong in all directions, is perfectly uniform in its structural character, and is almost absolutely homogeneous as to strain. It would be expected, therefore, that the diagrams

PLATE I.

AUTOGRAPHIC STRAIN-DIAGRAMS OF WOODS PRODUCED BY THE TESTING MACHINE OF PROFESSOR R. H. THURSTON.



obtained by breaking such a material would differ from those of the woods, in having a smoother and more regular form, and this is shown to be actually the case by observation of the curves of cast-steel, cast-iron, bronze, and others of the more homogeneous metals and alloys.

Some of the metals, it will be noticed, yield diagrams of less regular form. Wrought-iron, as usually made, has a somewhat fibrous structure, which is produced by particles of cinder, originally left in the mass by the imperfect work of the puddler while forming the ball of sponge in his furnace, and which, not having been removed by the squeezers or by hammering the puddle ball, are, by the subsequent process of rolling, drawn out into long lines of non-cohering matter, and produce an effect upon the mass of metal which makes its behaviour, under stress, somewhat similar to that of the stronger and more thready kinds of wood. In the low steels, also, in which, in consequence of the deficiency of manganese accompanying, almost of necessity, their low proportion of carbon, this fibrous structure is produced by cells and "bubble holes" in the ingot, refusing to weld up in working, and drawing out into long microscopic, or less than microscopic, capillary openings.

In consequence of this structure we find, as we should have anticipated, a depression interrupting the regularity of their curves, immediately after passing the limit of elasticity, precisely as the same indication of the lack of homogeneousness of structure was seen in the diagrams produced by locust and hickory.

The presence of internal strain constitutes an essential peculiarity of the metals which distinguishes them from organic materials. The latter are built up by the action of molecular forces, and their particles assume naturally, and probably invariably, positions of equilibrium as to strain. The same is true of naturally formed organic substances. The metals, however,

PLATE

AUTOGRAPHIC STRAI

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TESTING MACHINE OF PROFE

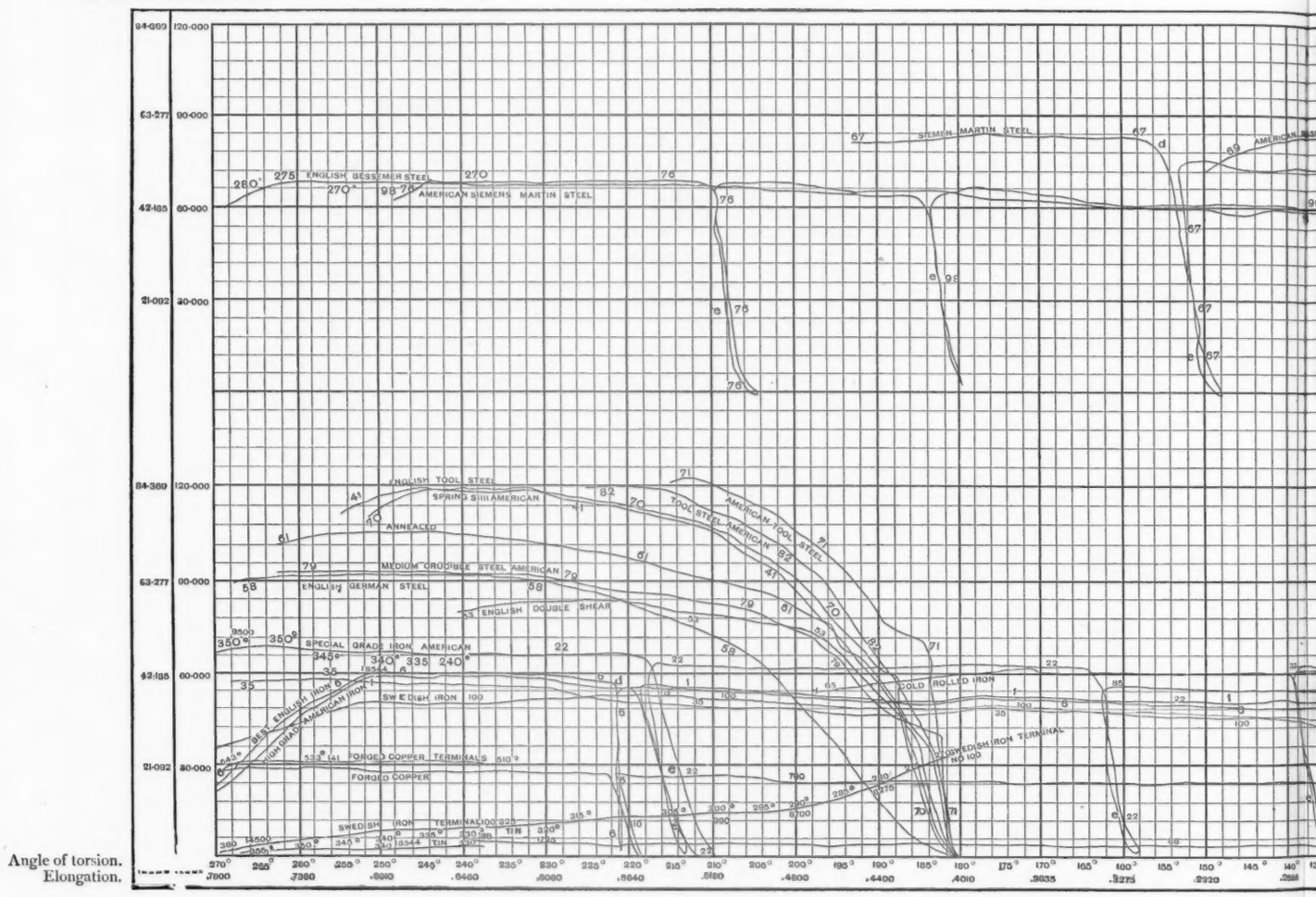
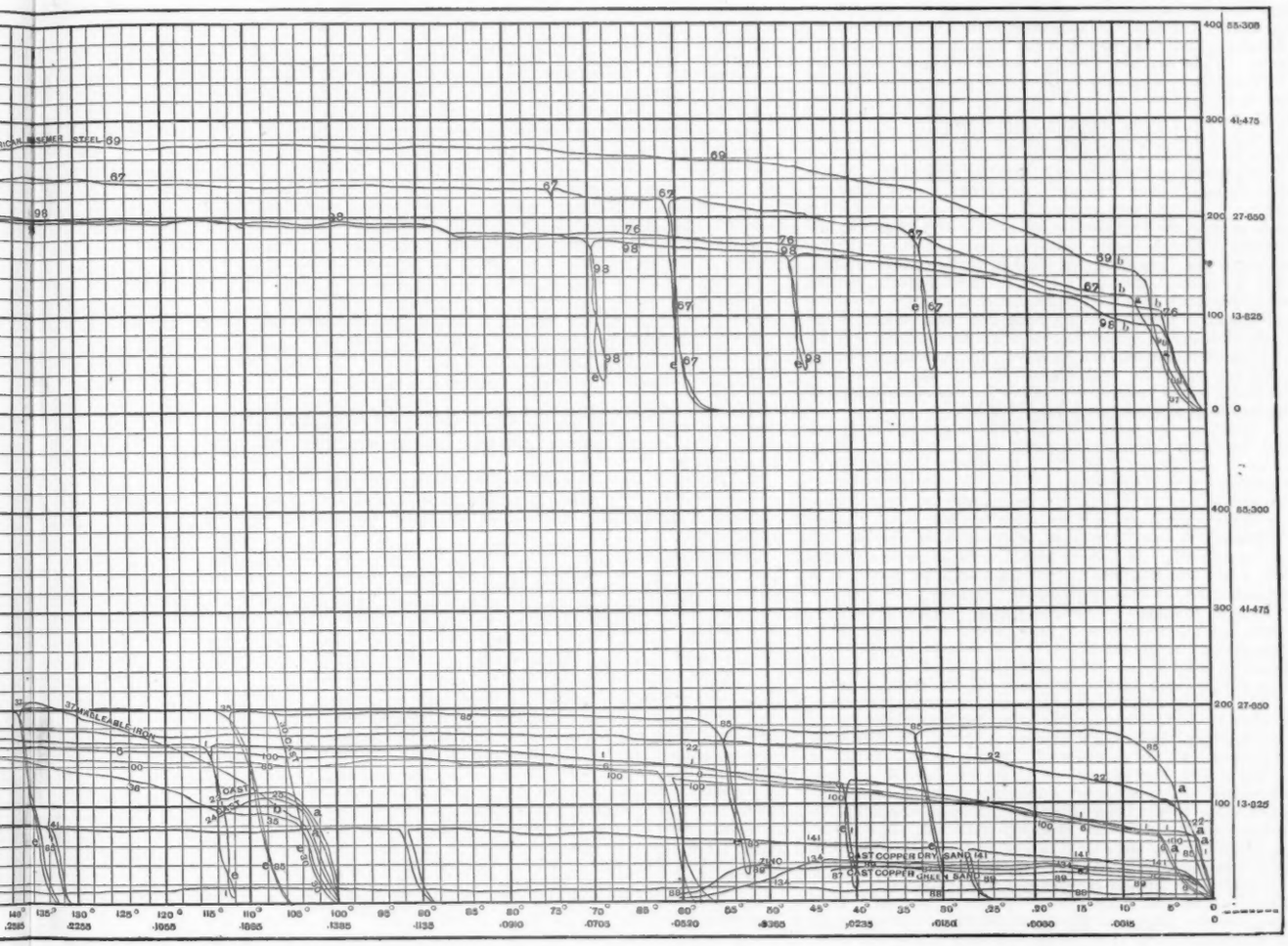


PLATE II.

AII-DIAGRAM OF METALS

DUCED BY THE

ROFESSOR R. H. THURSTON.



are given form by external and artificially produced forces. Their molecules are compelled to assume certain relative positions, and those positions may be those of equilibrium, or they may be such as to strain the cohesive forces to the very limit of their reach. It even frequently happens, in large masses, that these internal strains actually result in rupture of portions of the material at various points, while in other places the particles are either strongly compressed, or are on the verge of complete separation by tension. This peculiar condition must evidently be of serious importance, where the metal is brittle, as is illustrated by the behaviour of cast-iron, and particularly in ordnance. Even in ductile metals it must evidently produce a reduction in the power of the material to resist external forces. This condition of internal strain may be relieved by annealing hammered and rolled metals, and by cooling castings very slowly, in order that the particles may assume, naturally, positions of equilibrium. In tough and ductile metals, internal strain may be removed by heating to a high temperature and then cooling under the action of a force approximately equal to the elastic resistance of the substance. This process, called "thermo-tension," was first used by Professor Johnson in the course of his experiments as a member of a Committee of the Franklin Institute, in 1836,[1] and the effect of this action in apparently strengthening the bars so treated, was stated in the report of the committee. The fact that this effect was very different with different kinds of iron was also noted, but it does not appear that the cause of this, which they term "an anomalous" condition of the metal was discovered by them.

Metals which are very ductile may frequently be relieved of internal strain, also, by simply straining them while cold to the elastic limit, and thus dragging all their particles into extreme positions of tension, from which, when released from strain, they may all spring back into their natural and unstrained positions of equilibrium. This fact, which does not seem to have been previously discovered by investigators of this subject, will be seen to have an important bearing upon the resisting power of materials, and upon the character of all formulas in which it may be attempted to embody accurately the law of resistance of such materials to distorting or breaking strain.

Since straining the piece to the limit of elasticity brings all particles subject to this internal strain into a similar condition, as to strain, with adjacent particles, it is evident that indications of the existence of internal strain, and through such indications a knowledge of the value of the specimen, as affected by this condition, must be sought in the diagram, before the sharp change of direction which usually marks the position of the limit of elasticity is reached. As already seen, the initial portion of the diagram, when the material is free from internal strain, is a straight line up to the limit of elasticity. A careful observation of the tests of materials of various qualities, while under test, has shown that, as would, from considerations to be stated more fully hereafter, in treating of the theory of rupture, be expected, this line, with strained materials, becomes convex towards the base line, and the form of the curve, as will be shown, is parabolic. The initial portion of the diagram, therefore, determines readily whether the material tested has been subjected to internal strain, or whether it is homogeneous as to strain. This is exhibited by the direction of this part of the line as well as by its form. The existence of internal strain causes a loss of stiffness, which is shown by the deviation of this part of the line from the vertical to a degree which becomes observable by comparing its inclination with that of the line of elastic resistance, obtained by relaxing the distorting force—*i. e.* the difference in inclination of the initial line of the diagram and the lines of elastic resistance, *e*, *e*, *e*, indicates the amount of existing internal strains.

7. *Forged Iron.*—In Plate II. the curves numbered 6, 1, 22 and 100, are the diagrams produced by three characteristic grades of wrought-iron. The first is a quality of English iron, well known in our market as a superior metal. The second is one of the finest known brands of American iron, and the third is also American make, but it does not usually come into the market in competition with well known irons, in consequence of the high price which is consequent upon the necessary employment of an unusual amount of labour, in securing its extraordinarily high character.

No. 6 at first yields rapidly under moderate force, only about 50 foot-pounds of torsional moment being required to twist it 5°. It then rapidly becomes more rigid, as the internal strains, so plainly indicated, are lost in this change of form, and at 6° of torsion, the resistance becomes 60 foot-pounds, as measured at *a*. Here the elastic limit is reached. The next 3° produce no increase of resistance. This fact shows that this iron, which was not homogeneous as to strain, is also not homogeneous in structure. We conclude that it must be badly worked and seamy, and that it may have been rolled too cold; the former is the probable reason of its lack of homogeneous structure, the latter gave it its condition of internal strain. After the first 9° of torsion, resistance steadily rises to a maximum, which is reached only when just on the point of rupture, and the piece finally commences breaking at 250°, and is entirely broken off at 285°. Its maximum elongation, whose value is proportionable to the reduction of section noted with the standard testing machines, is 0·691. The terminal portion of the line after rupture commences, is not usually accurate as a measure of the relation of the force to the distortion. The increase of resistance between the angle 9° and the angle of rupture is produced by the additional effort in resistance due to the "flow" or drawing out of particles, as already indicated, and the precise effect of which will be noticed at length in a succeeding section relating to the theory of rupture.

Applying the scale for tension, which in the case of these curves was very exactly 24,000 lbs. per square inch for each inch measured vertically on the diagram, we find that the elastic limit was passed under a stress equivalent to a tension of 19,800 lbs. per square inch, and that the ultimate tenacity was 59,200 lbs. per square inch. When nearly at the maximum the specimen was relieved from stress, the pencil descending to the base line, and the elasticity of the piece produced a certain amount of recoil. The angle intercepted between the foot of this nearly vertical line, *c*, and the origin at *o*, measures the set, which is nearly almost entirely permanent. The distance, measured from the foot of the perpendicular, let fall upon the axis of abscissas, from the head of this line to the foot of the line *e*, measures the elasticity, and is inversely proportional to the modulus. A comparison of the inclination of the line made by the pencil in re-ascending, on the renewal of the strain with the initial line of the diagram, gives the indication of the amount of internal strain originally existing in the piece.

It will be noticed that the horizonal movement of the pencil is recommenced at I, under a higher resistance than was recorded before the elastic line was formed. In this case the piece has been left under strain for some time before the stress was relieved, and the peculiarity noted is an example of an increase of resistance under stress,[1] or more properly of the elevation of the elastic limit, of which more marked examples will be shown subsequently.

The exceptional stiffness and limited elastic range here shown, as compared with the other examples given, is probably a phenomenon accompanying and due to this increase of resistance under stress.

Examining No. 1 in a similar manner, we find that it is far freer from internal strain than No. 6, its initial line being much more nearly straight and rising more rapidly. It is rather less homogeneous in structure, and is forced through an arc of 6°, after having passed its elastic limit, before it begins to offer an increasing resistance. It is evidently a better iron, but less well worked, and, as shown by the position of the elastic limit, is somewhat harder and stiffer. No. 1 retains its higher resistance quite up to the point at which No. 6 received its incidental accession of resistance by standing under strain, and the two pieces break at, practically, the same point, No. 1 having slightly the greater ductility. When the "elastic line," *e*, is formed, just before fracture, it is seen that No. 1 has a greater elastic range and a lower modulus than No. 5. It should be observed that the line by which the pencil descends to the base line has usually no value, owing to the fact that no care is generally taken to remove the stress as gradually as it is applied. When such care is taken, the lines are usually coincident, and do not form the loop here seen. It will also be noticed that these lines often cross each other, that on the right being the important line. The elastic line formed by No. 1 at between 40° and 45° of torsion is seen to be very nearly parallel with that obtained near the terminal portion of the diagram, and illustrates the fact here first revealed to the eye, that the elasticity of the specimen remains practically unchanged up to the point of incipient rupture, and this fact corroborates the deductions of Wertheim[2] and others who came to this conclusion from less satisfactory modes of research. All experiments yet made give a similar result.

No. 22 illustrates the characteristics of a metal which probably represents one of the best qualities of wrought iron made in this or in any other country, and with which every precaution has been taken to secure the greatest possible perfection, both in the raw material and in its manufacture. The fact that it finds a market at sixteen cents a pound proves that even such care and expense are well applied. The line of this diagram, starting from *O*, rising with hardly perceptible variation from its general direction, turns, at the elastic limit *a*, under a moment of about

[1] "Journal Franklin Institute," 1836-7.

[1] *Vide* "Transactions," vol. ii. p. 290.

[2] *Vide* "Annales de Chimie et de Physique."

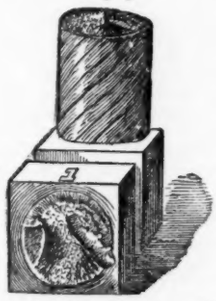
80 foot-pounds, equivalent to a tension of about 24,000 pounds per square inch; and with between 2° and 3° of torsion only, and thence continues rising in a curve almost as smooth and regular as if it had been constructed by a skilful draughtsman. Reaching a maximum of resistance to torsion of 220 foot-pounds, and an equivalent tensile resistance of over 66,000 pounds per square inch, at an angle of 345°, it retains this high resistance up to the point of rupture, some 358° from its starting point. The maximum elongation of its exterior fibres is 1·2, making them at rupture 2·2 times their original length. This would produce a probable breaking section in the common testing machine equal to 0·4545 of the original section.[1]

From the beginning to the end this specimen exhibits its superiority in all respects over the less carefully made irons, Nos. 1 and 6, which, it should be remembered, are themselves deservedly known as good brands. The homogeneousness of No. 22 is almost perfect, both in regard to strain and to structure, the former being indicated by the straightness of the first part of the diagram and its parallelism with the "elastic line," *e*, produced at 217½°, and the latter being proven by the beautiful accuracy with which the curve follows the parabolical path indicated by our theory as that which should be produced by a ductile homogeneous material. At similar angles of torsion, No. 22 offers invariably much higher resistance than either Nos. 1 or 6; and this superiority, uniting with its much greater ductility, indicates an immensely greater resilience. It is evident that for many cases, where lightness combined with capacity to carry live loads and to resist heavy shocks are the essential requisites, this iron would be by far preferable, notwithstanding the cost of its manufacture, to any of the cheaper grades. Comparing their elasticities, as shown at 210°, 215°, it is seen that No. 22 is about equally stiff and elastic with No. 1, while both have a wider elastic range and are less rigid, and hence are softer than No. 6, whose elastic line is seen at 221°. All of the characteristics here noted can be accurately gauged by measuring the diagrams, and constants are readily obtained for all formulas, as illustrated in a later section of this paper, in which the construction of formulas and the determination of constants will be made the subject of investigation.

No. 100 is the curve obtained from a piece of Swedish iron, marked [GF]. Its characteristics are so well marked that one familiar with the metal would hardly fail to select this curve from among those of other irons. Its softness and its homogeneous structure are its peculiarities. Its curve, at first, coincides perfectly with that of No. 6. It has, however, slightly less of the condition of internal strain, and a somewhat higher limit of elasticity. The elastic limit is found at 5½° of torsion, and at a stress of 65 foot-pounds of moment, equivalent to 19,500 pounds on the square inch in tension. Its increase of resistance, as successive layers are brought to their maximum and begin to flow, is very nearly the same as that of the specimens Nos. 1 and 6, and the line lies between the diagrams given by these irons up to 30°, and then falls slightly below the latter. At 220° it attains a maximum resisting power, and here the outer surface begins to rupture, after an ultimate stretch of lines formerly parallel to the axis, amounting to 0·564. Had this elongation taken place in the direction of strain, as in the usual form of testing machine, it would have produced a reduction of section to 0·64, the original area.[2] At this point the stress in tension equivalent to the 176 foot-pounds of torsional stress is 52,800 pounds per square inch. From 250° the loss of resistance takes place rapidly, but the actual breaking off of the specimen did not occur until it had been given a complete revolution. This part of the diagram distinguishes the metal from all others, and shows distinctly the exceptionally tough, ductile, and homogeneous character which gives the Swedish irons their superiority in steel making. No. 22, even, although much more extensible, is harder than No. 100, and yields more suddenly when it finally gives way.

A comparison of the results here recorded with those obtained by Styffe[3] will afford a good basis upon which to form an idea of the accuracy as well as the convenience of this method of deriving them. An examination of the broken test piece gives some evidence confirmatory of the record. The exterior surface of the twisted portion has an appearance intermediate between that of No. 1, fig. 5,[4] and No. 22, fig. 7, with an evident tendency to "kink." The surface of fracture is lighter and more lead-like than even No. 22, and its "fibre" is finer and texture more plastic in appearance. It is beautifully uniform in character. On one end of this specimen, where a piece had been nicked and then broken off by a sharp blow, the absence of all fibrous appearance, and the granular texture and magnificently fine, regular grain, are very marked, and indicate that the material is entitled to its established position as the purest metal known in the market. The specimens themselves furnish almost as valuable information, after test, as the diagrams contain, and should always be carefully inspected, with a view to securing

Fig. 5.



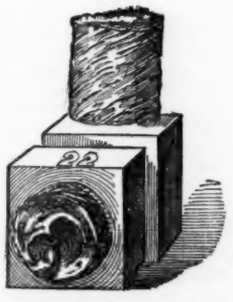
additional or corroborative information. Fig. 5 is a sketch of specimen No. 1, and shows its somewhat granular fracture, and the seamy structure produced by a defective method of working. Fig. 6, from specimen No. 16, more nearly resembles that which

Fig. 6.

gave the diagram marked 6. The metal is seen to be good, tough, and better in quality than No. 1, but it is even more seamy, and even less thoroughly worked, as is evidenced by the cracks extending around the neck, and by the irregularly distributed flaws seen on its end.

Fig. 7 exhibits the appearance of No. 22 after fracture, and

Fig. 7.



shows even more perfectly than the pencilled record the splendid character of the material. The surface of the neck was originally smoothly turned and polished, and carefully fitted to gauge. Under test it has become curiously altered, and has assumed a rough, striated appearance, while the helical markings extend completely around it. The end has the peculiar appearance which will be seen to be characteristic of tough and ductile metals, and the uniformly bright appearance of every particle in the fractured section shows how all held together up to the instant of rupture, and that fracture finally took place by true

[1] Compare Kirkaldy, "Strength of Iron and Steel," pp. 111, 185, for reduction in Yorkshire and Swedish bars. The elongation there given has, of course, no value as a measure of ductility.

[2] Compare Styffe, "Strength of Iron and Steel," p. 133, No. 26-30.

[3] *Ibid.*

[4] From an article in the "Scientific American," of January 17th, 1874, on "Testing the Quality of Iron, Steel, and other metals without Special Apparatus."

shearing. Rupture by torsion thus brings to light every defect, and reveals every excellence in the specimen. Rupture by tension rarely reveals more than the mere strength of the material.

8. *Low Steels.*—In Plate II., and above the curves just described, are a set obtained during experiments on "low steels," produced by the Bessemer and Siemens-Martin processes. In general character, the curves are seen to resemble those of the standard irons, illustrated by Nos. 1 and 6. The irons contain usually barely a trace of carbon. These steels contain from one-half to five-eighths of one per cent. The irons are made by a process which leaves them more or less injured by the presence of impurities, from which the utmost care can seldom free them. The steels are made from metal which has been molten and cast, a process which allows a far more complete separation of slag and oxides. The low steels, however, are liable to an objectionable amount of porosity, due to the liberation of gas while the molten mass is solidifying, whenever the spiegeleisen, employed as a conveyer of carbon, is not very rich in manganese. The results of these differences in constitution and treatment are readily seen by inspecting the curves. They show a stiffness equal to No. 6, and about the same degree of internal strain. They contain a sufficient number of the capillary channels, produced by drawing down the pores while working the ingot into bar, to cause a lack of homogeneousness in structure, very similar to that produced in iron by cinder. They have a much higher elastic limit, and greater strength, and the softer grades have great ductility. In resilience, these softest steels excel all other metals, except the unusual example, No. 22, and are evidently the best materials that are now obtainable for all uses where a tough, strong, ductile metal is needed to sustain safely heavy shocks. A comparison of the diagrams of two competing metals may thus be made to indicate how far a difference in price should act as a bar to the use of the costlier one. For many purposes, a metal having double the resilience of another is worth more than double price. For general purposes, a comparison of the resilience of the metals within the elastic limit is of supreme importance. No. 6 is seen to have more resilience within this limit than No. 1, and the steels far more than either; but No. 1 would take a set of considerable amount far within the true elastic limit, as indicated at *a*. The most valuable measure is obtained by determining the area intercepted between the "elastic line" and the perpendicular let fall from its upper end; this measures the resilience of elastic resistance, which is the really important quality.

No. 98 was cut from the head of an English Bessemer rail made from unmixed Cumberland ores. It contains nearly 0·4 per cent. carbon. It is quite homogeneous, has a limit of elasticity at 88 foot-pounds of torsional, or 26,400 lbs. per square inch tensile stress, approaches its maximum of resistance rapidly, and, at 210°, the torsional moment becomes 225 foot-pounds, equivalent to 67,500 lbs. per square inch tensile stress. It only breaks after a torsion of 283°, and with an ultimate elongation of 80 per cent., equivalent to a reduction of cross section to 0·556.

No. 76 is a Siemens-Martin steel made from mixed Lake Superior and Iron Mountain ores, and contained about the same amount of carbon as the preceding. It contains rather more phosphorus, which probably gives it its somewhat greater hardness, its higher limit of elasticity and its somewhat reduced ductility. Its elastic limit is found at 104 foot-pounds of torsion, or 31,200 lbs. tensile resistance, and its ultimate strength is almost precisely that of the preceding specimen. Its elongation is 0·66 maximum. Unless more seriously affected by extreme cold than No. 98, it would be preferred for rails, and, perhaps, for most purposes.

No. 67 is a somewhat "higher" steel, made by the same process. It is less homogeneous than the two just examined, has greater strength and a higher elastic limit, but less ductility. Its resilience is very nearly the same as that of Nos. 98 and 76. The elasticity of all of these steels seems very exactly the same. The ductility of No. 67 is measured by 0·40 elongation. At *d* is seen another illustration of elevation of the elastic limit. The piece was left twenty-four hours under maximum stress. The torsional force was then removed entirely. On renewing it, as is seen, the resistance of the specimen was found increased in a marked degree.

No. 69 is an American Bessemer steel, containing not far from 0·5 per cent. carbon. The same effect is seen here that was before noted, an increase of hardness, a higher elastic limit, and greater strength, obtained, however, by some sacrifice of both ductility and resilience. The elastic limit is approached at 130 foot-pounds of torsional moment, or 39,000 lbs. tensile, and the maximum is 280 foot-pounds of moment and 84,000 lbs. tensile resistance at 133°. Its maximum angle of torsion is 150°, its elongation 0·24

No. 85 is a singular illustration of the effects of what is probably a peculiar modification of internal strain. It seems to have no characteristics in common with any other metal examined. Its diagram would seem to show a perfect homogeneousness as to strain and a remarkable deficiency of homogeneity in structure. It begins to exhibit the indications of an elastic limit at *a*, under a torsional moment of 110 foot-pounds, or an apparent tensile stress of 33,000 lbs. per square inch, and then rises at once by a beautifully regular curve to very nearly its maximum at 16° and 176 foot-pounds. The maximum is finally reached at 130°, and thence the line slowly falls until fracture takes place at 195°. The maximum resistance seems[1] to be very exactly 60,000 lbs. to the square inch. Its maximum elongation for exterior fibres is about 0·23. The resilience taken at the elastic limit is far higher than with common iron, and it is seen that this metal, in many respects, may compete with steel. Its elasticity is seen to remain constant wherever taken. This singular specimen was a piece of "cold rolled" iron. It is probably really far from homogeneous as to strain, but its artificially-produced strains are symmetrically distributed about its axis, and being rendered perfectly uniform throughout each of the concentric cylinders into which it may be conceived to be divided, the effect, so far as this test, or so far as its application as shafting, for example, is concerned, is that of perfect homogeneousness. The apparently great deficiency of homogeneousness in structure is readily explained by an examination of the pieces after fracture; they are fibrous and have a grain as thread-like as oak; their condition is precisely what is shown by the diagram, and the metal itself is as anomalous as its curve.

8. *Tool Steels.*—The "tool steels" differ chemically from the "low steels" in containing a higher percentage of carbon, and usually in being very nearly, if not absolutely, free from all injurious elements. They are made in crucibles, by melting down the blister steels, which are the crude product of the process of cementation, or sometimes, by melting a charge composed of selected iron, a small proportion of manganese bearing alloy and the proper amount of carbon. Containing a higher proportion of carbon than the preceding class of metals, it is comparatively easy to secure homogeneousness by the introduction of manganese, and by the same means to eliminate very perfectly the evil effects of any small proportion of sulphur that may be present. Their comparatively large admixture of carbon makes them harder and reduces their ductility, and since the reduction of ductility occurs to a greater degree than the increase of strength, the effect is also to reduce their resilience. The working of these metals is more thorough than is that of the less valuable steels, or of iron. They are cast in comparatively small ingots, and are frequently drawn down under the hammer instead of in the rolls, and are thus more completely freed from that form of irregularity in structure noticed so invariably in steels otherwise treated. The effect of increasing the proportion of carbon is to confer upon iron the property of hardening when heated to a high temperature and suddenly cooling, and the invaluable property of "taking a temper," *i. e.* of assuming, under proper treatment, any desired degree of hardness. The hard steels are, however, comparatively brittle, the hardening being secured at the expense of ductility. The effect produced upon the tenacity of unhardened steel, by increasing proportions of carbon is somewhat variable, since it is influenced greatly by the presence of other elements. For good steels, unhardened, the writer has been accustomed to estimate tenacity by the following formula, which is approximately accurate, and may be often found useful:

$$T = 60{,}000 + 70{,}000\ C.$$

in which T represents the tenacity in pounds per square inch, and C is the percentage of carbon contained in the metal. This subject will be considered at greater length after a series of experiments have been made to obtain more exact determinations.

Referring to Plate II., a set of diagrams will be found, having their origin at 180°, which are *facsimiles* of those automatically produced during experiments upon various kinds of tool steels.

No. 58 is an English metal, known in the market as "German crucible steel." It is remarkable as having a condition of internal strain, which has distorted its diagram to such an extent as to completely hide the usual indication of the elastic limit. A careful inspection shows what may be taken for this point at about 14½° of torsion, when the twisting moment was about 120 foot-pounds, and the tensile resistance 36,000 lbs. per square inch. The metal is homogeneous in structure, has an ultimate resistance of 302 foot-pounds of moment, or 90,600 lbs. per square inch

[1] With an exceptional case, of which this is an example, the scale for tension is incorrect. The tensile strength is probably higher than here given.

tensile resistance. Its resilience is evidently inferior to that of the softer metals, and also less than the next higher and better grades. This metal contains about 0·60 to 0·65 per cent. carbon. Its elongation amounts to 0·045.

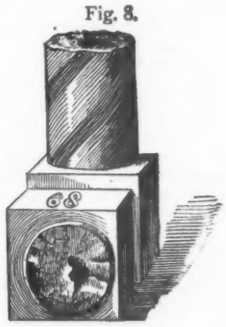
No. 53 is an English "double shear steel," of evidently very excellent structure, but less strong and resilient than the preceding. Its exterior fibres are drawn out three per cent.

Nos. 41 and 61 are two specimens of one of the best English tool steels in our market. The first was tested as cut from the bar, but the second was carefully annealed before the experiment. In this instance, annealing has caused a slight loss of resilience, as well as a decided loss of strength. In No. 41 the limit of elasticity can hardly be detected, but seems to be at about the same point as in No. 61, at near 130 foot-pounds moment and 39,000 lbs. tension. The ultimate strength is nearly 119,000 lbs. per square inch. The proportion of carbon is very closely 1 per cent. Its section would reduce by tension 0·05.

No. 70 is an American "spring steel," rather hard, but, as shown by its considerable resilience, of excellent quality, resembling remarkably the tool steel No. 41. It differs from the latter, apparently, by its much higher elastic limit. It is possible that this may have been caused by more rapidly cooling after leaving the rolls in which it was last worked. It is evident that, for exact comparison, all specimens should be equally well annealed, or should be tempered in a precisely similar manner, and to the same degree.

Nos. 71 and 82 are American tool steels, containing about 1·15 of carbon. The former is notable as having an elastic limit at 69,000 lbs., and a probable deficiency of manganese, producing the usual indication of heterogeneous structure. Both of these steels lack resilience, and are less well adapted for tools like cold chisels, rock drills, and others which are subjected to blows, than for machine tools. They have a maximum elongation respectively of but 0·013 and 0·03.

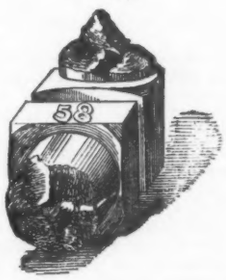
Fig. 8.



Interesting and instructive as the study of these curves may be made, the information obtained from them is supplemented, in a most valuable manner, by that obtained by the inspection of the fractured specimens, upon which the peculiar action of a torsional strain has produced an effect in revealing the structure and quality of the metal that could be obtained in no other way.

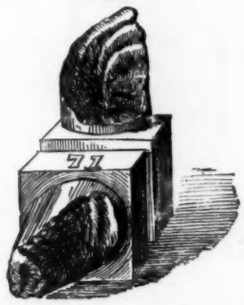
Fig. 8 represents the appearance of No. 68, and fig. 9 that of No. 58, while the peculiarities of the finest tool steels are seen

Fig. 9.



in No. 71, as shown in fig. 10. The smooth exterior of No. 68, which is a companion specimen to that giving diagram 69, and its bright and characteristic fracture, resembling that of No. 22 somewhat, together indicate its nature perfectly, the first feature proving its strength and uniformity of structure, and the second showing, even to the inexperienced eye, its toughness. This is a representative specimen of low steels. No. 58 is seen to have retained, even more than No. 68, its original smoothly polished surface. It fracture is less waxy, and much more irregular and sharply angular. The crack running down the side of the neck shows its relationship to the shear steels, which much oftener exhibit this effect of strain, in consequence of their lamellar character. No. 58 is evidently intermediate in its character between the soft steels, like No. 68, and the tool steels which are represented by No. 71, fig. 10. In this test piece the fracture is ragged

Fig. 10.



and splintery, and the separated surfaces have a beautifully fine even grain, which proves the excellence of the material. The surface, which was turned and polished in bringing the metal to size, remains as perfect as before the specimen was broken. By an inspection of the broken test pieces in this manner, the grade of the steel, and such properties also as are not revealed by an examination of the diagram of strain are very exactly ascertained by a novice, and to the practical eye the slightest possible variations of character are readily distinguishable.

9. *Cast-iron.*—The diagrams of strain having their commencement at 100° have been obtained from cast-iron and from malleableized cast-iron.

Nos. 23 and 24 are those given by a good dark grey foundry iron from Pennsylvania. No. 25 represents the curve of light grey scrap, and No. 30 is from a very fine white Lake Superior charcoal iron. The latter is seen to be exceeding hard and rigid, the resistance of the piece rising very precisely in proportion to the angle of torsion, until it snaps at last under a moment of over 200 foot-pounds, equivalent to a tension of 60,000 lbs. per square inch, and with a maximum elongation of one-tenth of 1 per cent. This is a most extraordinary resistance; but it is evident that, notwithstanding its immense strength, this material would be valueless for ordinary purposes, in consequence of its excessive brittleness. When the torsional effort had reached about one-half its maximum amount, the piece was released. The pencil retreated along a nearly vertical line, *e*, which it again traversed as the strain was gradually renewed. Here, as in many other cases, where a similar experiment was made, evidence is given of the truth of the statement originally make by Hodgkinson,[1] that every load produces a set. As will be shown subsequently, however, it is not true in perfectly homogeneous bodies free from strain, and within their elastic limit. The light grey iron has a limit of elasticity at near one-half the maximum reached by the white iron, without any sign of reaching the limit of its elasticity. The grey has more ductility than the white iron, but has only about two-thirds the resilience of the latter. The dark grey irons are evidently better than either of the lighter grades, except in power of carrying an absolutely static load. The actual stretch of the outer surface particles is very nearly the same in all three. They are excellent specimens of their class, and considerably better than ordinary irons.

No. 37 is a "malleableized cast-iron," made from the extraordinary metal illustrated in No. 30. The process of malleableizing consists in decarbonization by heating the casting made from good white iron, in contact with iron oxide or other decarbonizing material. Without removing any other constituent than the carbon, it produces a crude steel or an impure wrought-iron. When performed in the usual manner, melting the cast-iron in a cupola in contact with the fuel, and with some flux, and then carrying the process of malleableizing to the usual extent, a metal is obtained such as is illustrated by the diagram marked 37. It retains the strength of the cast-iron, and acquires some ductility.

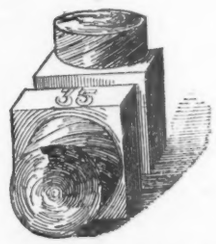
No. 30 yielded 7 deg. before fracture, while No. 37, vastly more ductile and resilient, only broke after a torsion of 39 deg., and a maximum elongation of 2 per cent. Taking the precau-

[1] "Reports of British Association," also "Civil Engineer and Architect's Journal."

tion to melt the iron in an "air furnace"—a form of "reverberatory"—and conducting the process of malleableizing more carefully, a still more valuable material was obtained.

No. 35 represents this iron. Its resemblance to wrought-iron, both in appearance of fracture, and in its strength and ductility,

Fig. 11.



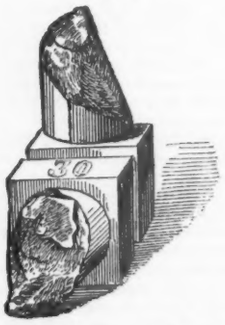
are greatly increased. It has a high limit of elasticity—over 20,000 lbs. per square inch—and such ductility that it only breaks after a torsion of nearly 168°, and an elongation of "fibre" of 0·35. It is not very homogeneous, but it is as strong, and almost as tough as a good wrought-iron. This material has especial value for many purposes, because of the facility with which awkwardly shaped pieces can be made of it. In many cases, it will prove as good as wrought-iron and far cheaper.

Fig. 11 shows the appearance of this last specimen. Its resemblance to wrought-iron is very noticeable. The lines

Fig. 12.

running like the thread of a screw around the exterior of the neck, and the smooth even fracture in a plane precisely perpendicular to the axis, are the instructive features. Fig. 12, representing No. 33, is a specimen similar in character to No. 37. The comparative lack of ductility, its less regular structure, and its less perfect transformation are perfectly exhibited. Fig. 13 is an excellent cut of the white iron as cast and without malleableizing. Its surface where fractured, has the general appearance of broken tool steel. The colour and texture of the metal are distinctive, however. It has none of the "steely grain." Fig. 14 represents the dark grey iron. Its colour, its granular structure and coarse grain are markedly characteristic, and no one can fail to perceive, in the specimen, the general character which is exactly given by the autographic diagrams of the testing machine.

Fig. 13.



10. *Other Metals.*—The diagrams numbered 87, 88 and 89, are those of copper, tin and zinc. These specimens are all of cast metal, carefully selected under the direction of the writer and moulded and cast at the Stevens Institute of Technology. They exhibit neatly the wonderful superiority which the various kinds of iron and steel possess over the other useful metals. These metals all take a set under very small strains, pass their

Fig. 14.

limits of elasticity at some indeterminable, but evidently low point, and possess very slight tenacity.

Zinc, No. 89, by the regularity of its curve shows a very uniform structure. It increases very gradually in resistance to torsion, until it reaches the angle 50°, at which point it has a moment of torsional resistance of 36 foot-pounds, and a maximum tenacity of about 10,800 lbs. per square inch. It loses its power of resistance, after rupture commences, as regularly, but not as slowly, as it acquired it, and rupture becomes complete at 63°. Its resistance is exceedingly small, and it is evidently unfit to bear either static or dynamic force. Its stretching power has a maximum of 0·04.

Tin, No. 88, is equally remarkable for its exceedingly feeble resistance and its great ductility. The specimen was excellent, both in quality of metal and in closeness of structure, as was indicated by the clearness of the "tin cry" heard while undergoing the test, and by the fine, smooth, clean fracture. The character of the curve is similar to that of zinc, but has far greater extent. Its elastic limit is quite indeterminable. The outline of the diagram indicates very perfect homogeneousness. The maximum resistance to torsion is found at 240°, and under a stress of 19 foot-pounds. Its tenacity deduced from the diagram is, at most, but 5,700 lbs. per square inch. Rupture occurs very gradually, and the piece separated entirely at 355°. Notwithstanding its great ductility, its low tenacity produces a low resilience, although in this quality it excels zinc, which latter metal had nearly double its strength. Its elongation by tension would have reduced its section to 0·6 of the original cross area, if that reduction were proportional to the ductility shown by the diagram.

Copper, No. 87, cast in green sand, like the zinc and tin just described, was found, on examination of the fracture, to differ from them in being exceedingly porous. The effect of this fault has been to weaken it seriously. Its curve closely resembles that of zinc, but is abruptly terminated by the piece suddenly breaking off at 46°. It reaches a maximum sooner than zinc, at 29°, and its greatest resistance to torsion is 36 foot-pounds, or to tension 10,800 lbs. per square inch, precisely the same as zinc. Its ductility has a value of $1\frac{1}{2}$ per cent. Its resilience is somewhat less than that of zinc. Its limit of elasticity is difficult to determine, but has been taken at $1\frac{1}{4}°$ where the moment of resistance is 13 foot-pounds, equivalent very nearly to 3,900 lbs. tenacity per square inch.

No. 134 is the curve of cast copper, precisely similar to No. 87, but cast in a dry sand mould. The marked difference between these specimens is probably due, not only to the difference in degree of porosity which arises from the presence of vapour, which permeates the casting in one case, filling it with bubble holes, and which is almost unobservable in the last, but the slower cooling of the dry sand casting also probably produces its effect in strengthening the metal. This last specimen has a limit of elasticity at not far from $13\frac{1}{4}°$, and under a torsional stress equivalent to a tension of 5,400 lbs. per square inch. The maximum values of these quantities are found at 21°, and are 42 foot-pounds, and 12,600 lbs. per square inch respectively. The resilience of the specimen is much greater than that of the preceding, and its maximum elongation is ·026. Altogether, this is far better than the preceding, and it would seem that copper, and probably all its alloys, should, when possible, be cast in dry sand, to secure density and strength.

No. 141 is a piece of forged copper, hammered into a one-inch square bar, from a piece originally $3\frac{1}{2}$ in. wide and $\frac{3}{4}$ in. thick. The most striking property noticed is its immense duc-

tility, far exceeding that of any other piece of metal yet tested, and, in amount, many times as great as the cast metal. Its limit of elasticity is reached very quickly, although it is impossible to say precisely where it occurs. Comparing its "elastic line" with the initial portion of the curve, it is seen that the slightest force produces a set which is proportionally large as compared with the sets of other metals. The curve rises very regularly and gradually to a maximum, which is only attained, however, after a total angle of tension of 450°, and which measures 96 foot-pounds moment, or 28,800 lbs. per square inch. Rupture is finally obtained after a torsion of 543°. The maximum elongation is 210 per cent., the most elongated lines of particles being finally left of 3·100 times their original length. Had this change of form occurred by reduction of section, the fractured area would have been but ·323, the area of original section. The resilience of this piece of metal is evidently insignificant within the limit of which it would be seriously distorted by a blow, but is quite large in amount where resistance extends to the point of rupture. This is perfectly consonant with that knowledge of the material which every mechanic derives from experience with it. Here, however, we have a complete account of its properties, written out by the material itself with definite and accurate measures.

11. *General Conclusions.*—These plates, exhibiting the diagrams, which are the autographs of all the useful metals, illustrate sufficiently well the remarkable fulness and accuracy with which their properties may be graphically represented, and the convenience with which they may be studied, with the aid of so simple a recording machine. A comparison of results deduced as shown, with those obtained, so far as they can be obtained at all, the usual method of simply pulling the specimens asunder, and trusting to, sometimes, unskilful hands and an untrained observer, for the adjustment of weights and the registry of results, will indicate the close approximation of this method in even ascertaining the behaviour of the metal in tension. On examining the beautifully-plotted curves given by Knut Styffe, as representing the results of the experiments made by him and by his colleagues, with a tensile machine, no one can fail to be struck with the similarity of those diagrams to the curves here produced automatically, and it will be readily believed that not only must there be very perfect correspondence of results where the two methods are carefully compared, but, also, that any theory of rupture must be defective which does not apply to both cases. The equations of the curves here given and those of the curves obtained by Styffe must have forms as similar as the curves themselves.

The constant ratio here assumed between the torsional resistance and the tensile strength of the metals, and of homogeneous materials generally, is based upon a comparison of the results here given with those obtained from the irons by tensile test, by the writer, and is confirmed by a compilation of results given by other experiments on the same brands.

12. *Testing within the Limit of Elasticity.*—In determining the value of materials of construction, it is usually more necessary to determine the position of the limit of elasticity, and the behaviour of the metal within that limit, than to ascertain ultimate strength or, except perhaps for machinery, even the resilience. It is becoming well recognized by engineers who are known to stand highest in the profession, that it should be possible to test every piece of material which goes into an important structure and to then use it with confidence that it has been absolutely proven to be capable of carrying its load with a sufficient and known margin of safety. It has quite recently become a common practice to test rods to a limit of strain determined by specification, and to compel their rejection when found to take a considerable permanent set under that strain. The method here described allows of this practice with perfect safety. The limit of elasticity occurs within the first two or three degrees, and, as seen, the specimen may be twisted a hundred, or even sometimes two hundred times as far, without even reaching its maximum of resistance, and often far more than this before actual fracture commences. It is perfectly safe, therefore, to test, for example, a bridge rod up to the elastic limit, and then to place the rod in the structure, with a certainty that its capacity for bearing strain without injury has been determined, and that formerly existing internal strain has been relieved. The autographic record of the test would be filed away, and could, at any time, be produced in court and submitted as evidence—like the "indicator card" of a steam engine—should any question arise as to the liability of the builder for any subsequent accident, or as to the good faith displayed in fulfilling the terms of his contract. A special machine has been designed for this case.

13. The above will be sufficient to show the use and the value of this method. In the course of experiment upon a large number of specimens of all kinds of useful metals and of alloys, a number of interesting and instructive researches have been pursued, and some unexpected discoveries have been made. Before taking up the theory of rupture, the construction of equations, and the determination of their constants, a section will be devoted to an account of these investigations.

LANTEIGNE'S WOOD-ORNAMENTING MACHINE.

AN adaptation of the process of engraving by cylindrical pressure has been made by M. Urbain-Auguste Lanteigne, of Paris, who has applied it to the purpose of ornamenting wood surfaces. His process has been patented, but awaits development.

We bring before our readers some details concerning this ingenious invention, not only because it is new to the English public, but also on account of its interest to architects, builders, and others specially concerned in the interior decoration of our dwellings. It is far from improbable that it may eventually influence to a large extent the ornamental treatment of inside work.

In principle M. Lanteigne's machine is a rolling mill, in which a plate of wood takes the place of a plate of unlaminated metal. The wood which is ornamented by this process, passes through two cylinders, each turning in opposite directions, and brought sufficiently close to exert upon the wood such a pressure that it receives the desired pattern, raised or sunk, according to the cylinder adopted.

The engraving cylinders, otherwise termed matrix-cylinders, are obtained by processes the analogues of which have long been known in allied arts of reproduction. The artist makes his pattern upon a broad surface of bees-wax; from this a cast is taken in gutta-percha, and the gutta-percha cast becomes in its turn a mould for the matrix-cylinder, which is run in bronze or cast-iron.

A description of the machine as arranged for ordinary work, *i.e.*, for figuring a single surface, will suffice for an understanding of the general powers of the machine, the further capabilities of which will be recognized from a very few hints.

We have already stated the principle of this machine to be that of a rolling mill. Its frame is composed of two cast-iron uprights, built solidly into the ground, and maintained at their proper distance by plates and bolts. Each upright is grooved for bearings, which receive the extremities of two axles. On the first of these axles is mounted a smooth cylinder, corresponding to the motion-cylinder in a rolling mill; the other axle carries the matrix-cylinder. For keeping the cylinders at the distance required by the thickness of the wood, its hardness, &c., the axle-boxes are provided with female screws, the threads of which are set in opposite directions and connected by the same screw, which thus serves as a regulator. A table, supported by the uprights, and fixed at the level of the motion-cylinder, keeps up the pieces of wood as they pass between the cylinders, guiding them by screw-guides, or in any other fashion.

Upon the same principle conical cylinders and matrices can be made use of for the execution of ornaments of a circular form.

A third variety of use consists in the production of a pattern upon both sides of the same board or veneer. The arrangement of parts is then changed, two matrix-cylinders being set up vertically in the frame, at a distance fixed according to the thickness of the wood.

Lanteigne's process, finally, may be varied for the mechanical production of mouldings. It suffices for this to replace the matrix-cylinder by a mere wheel, cut out to a design the reverse of that desired for the moulding.

Some practice and experience would, of course, be required to judge of the motion requisite for certain patterns, or certain woods or qualities of woods; but the expense of working the wood is so trifling, that its ornamentation, which adds so much to its value, adds no perceptible amount to its cost, while it neither requires preparation for the process nor loses the important qualities thus inexpensively imparted.

MUGGETT'S System of Manufacturing Horse Nails.—E. J. BRAMWELL states that nails and wood screws have for many years been made by truly automatic machinery. The peculiarities about horseshoe nails are that they have to be driven into part of a living animal; that they have to go in straight, otherwise the horse would be lamed; and that they must be capable of being afterwards drawn out. After a large expenditure of capital, a machine was invented, which to all appearance made perfect nails, but they

turned out to be commercially valueless. A second machine constructed made perfect nails, but was unable to stand the wear and tear. On a third trial a durable machine was constructed, which is capable of making good marketable nails. Bars of Swedish iron are first heated for 30 seconds in a Siemens furnace, and, while at a white heat, thrown into a rolling mill, the rolls of which make 550 revolutions per minute; the bars are thus rolled out from a length of 3 ft. to about 7 ft., and are of an alternately small and large section throughout their length. The portions of the larger section form two heads, and those of the smaller two shanks. The author points out that without the invention of the Siemens furnace the first rolling would have been impracticable. After being passed through a set of cold shaping rolls, which correct the portion of the large section in the bars to the exact form required for the heads, they are taken to a shearing machine and cut up into separate nail blanks. The heads are afterwards pressed to the right shape in a die, the blanks being fed under the die by a wheel. They are then twice annealed and once rumbled, and finally passed through the shaping machine, in which they are squeezed between jaws to the right form.

One great difficulty that the inventors of the machine had to contend against was the prejudice on the part of the nail consumers in favour of *forged* nails, which it is almost impossible to make by machinery; the nails produced by this machine, however, will bear more bending than those produced under the hammer. In one night of 10 hours, 200,000 nails can be rolled by two men and three boys; 35,000 cut; 25,000 headed; and 20,000 shaped, in each of the latter cases by one girl.—*Paper read before the British Association, Bradford.*

NOTES ON SEWAGE AND MANURE AT THE LONDON INTERNATIONAL EXHIBITION, 1874.

AMONG the objects in the Industrial Department of this year's International Exhibition, a prominent place is occupied by models of sanitary arrangements and processes, mostly in operation, showing how to utilize the domestic offal which is comprised under the name of sewage.

One is somewhat struck with the large number of dry earth apparatus, as compared with models of the water systems; but still greater must be the astonishment of the visitor in finding as representatives of the utilization of the contents of sewers, nothing but precipitation processes. The direct irrigation process, carried out on so large a scale in England and Scotland, and, as we have reason to believe, extending in application with every day, is neither mentioned in the catalogue, nor could the writer of these lines discover anything in the Exhibition grounds bearing on the subject.

Of the various models, apparatus, &c., representing dry and wet closets, we have nothing to say in this review; we restrict ourselves to describing some of the methods showing the utilization of the sewage, or contents of dry closets, and appending such remarks and quotations as appear necessary to the fuller appreciation of the question.

The processes which deal with the yields of dry closets are foremost two: first, that of the Universal Charcoal and Sewage Company (Limited), Manchester; and, secondly, the Carbon Fertilizer Company (Limited), London. The former carbonizes street-sweepings of cities, and thus obtains a charcoal suitable for deodorization, and also for the filtration of waste and impure waters. There is a case with twelve compartments in Class IX. of the Exhibition which shows the various specimens prepared by the Company.

Compartment 1 [1] comprises raw street-sweepings, as collected by the town authorities of Salford, where the Company have erected kilns and retorts for the carbonizing of these refuse matters.

Sample 2 shows the charcoal obtained by the carbonization of the street-sweepings, just as it is delivered from the cylindrical retorts wherein the operation has been performed. The charcoal in this condition is used for making the manure exhibited in compartments 7 and 8.

No. 3 is the same charcoal as No. 2, after being subjected to grinding. In this condition it is eminently suitable for use as a deodorizer for any noxious, mephitic, or putrescent vapours. For "dry closets" it will be found the most perfect and efficient deodorant hitherto introduced; one-fourth or one-fifth of the quantity of this charcoal being required which would be necessary where dry earth is the absorbent. The analysis of this charcoal shows that it possesses, on the average, about twice the quantity of *pure carbon* which is found in the best animal charcoal.

Sample 4 is the same as the previous, but is much more finely ground, and carefully sifted through wire meshes giving 15,600 openings in the square inch. Owing to the quantity of pure silica in a state of infinitesimal division which it contains, this moulders' charcoal does not run before the hottest metal, but keeps its surface finely smooth and sharp. Founders who have used this charcoal give it a preference over ordinary Founders' Blacking at a much higher price.

In compartment 5 we meet with filtering charcoal in lump. It is made from a mixture of the raw street-sweepings shown in No. 1, with a clay free from sand, in certain proportions; the mass being thoroughly incorporated together, dried, and then carbonized. This charcoal has been found very efficient in the filtration of foul and impure waters, thoroughly removing the putrescible matter which they contained, and rendering them sweet, clear, and bright. Samples of the foulest sewage of Manchester, after passing through this charcoal, show no symptoms of any sediment, and remain perfectly odourless, though many months have elapsed since the filtration was performed. This charcoal will, on exposure to the air, recover its purifying property.

No. 6 is a finer specimen of the preceding sample.

No. 7 is designated as charcoal manure, and consists of charcoal No. 2, mixed with the night-soil collected by the Salford authorities on the "pail" system. The sample is said to contain 40 to 50 per cent. of night-soil, but no trace of its presence can be detected by the smell.

The contents of 8 are alike to that of section 7, and this, as well as the former, are designated as anti-wireworm manure, on the ground of being distasteful to worms, grubs, &c.

The specimens in 9, 10, and 11 are likewise charcoal for filtration. The street refuse, carefully incorporated with clay, free from sand, is subjected to carbonization, like the filtering charcoal shown in Nos. 5 and 6. The resulting charcoal possesses the highest efficiency as a filtering medium for watery liquids of every class. By using either this charcoal or that previously mentioned, all microscopic germs of life are removed from the water, which is thereby freed from all matters of a putrescible nature. This charcoal can be supplied of any suitable size, as shown. It also recovers its filtering properties and its porosity, after becoming "charged," by simple exposure to the air, as has been previously pointed out with the filtering charcoal made from street-sweepings. A sample of Manchester sewage filtered through this charcoal has had fish living in it ever since August 12th, 1873, and they still continue lively and healthy.

In the last compartment, the Company shows charcoal obtained from street-sweepings of Birmingham, where the streets are macadamized; and this coal presents no different view to the corresponding specimens.

An analysis of carbonized Salford street-sweepings, mixed with excreta and urine, shows the following figures:—

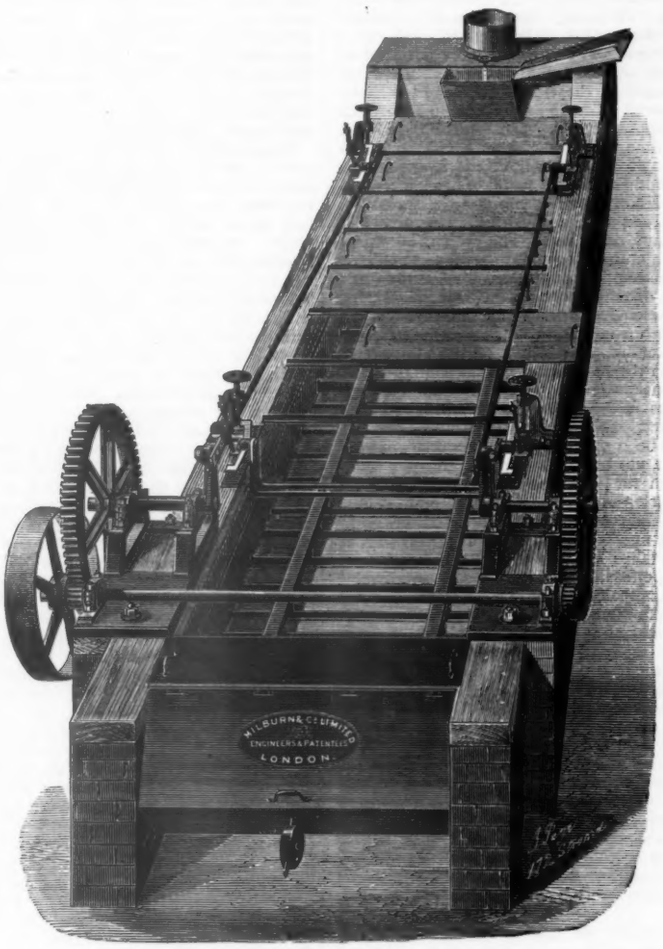
Moisture	13·880
Organic matter	26·340
Residue insoluble in acids	46·810
Portion soluble in acids	12·970
	100·000
Phosphoric acid	0·6150
Ammonia, by distillation	0·0133
Total nitrogen, by combustion	0·5600

As to collecting all the street refuse of a town, the night-soil of the houses, the sifting and separating of heterogenous portions, as broken pottery, old metals, &c., and finally, the calcining itself, all this together is asserted to cost less than 10*s.* per ton, whilst the minimum price of a ton of charcoal is put down at not less than 20*s.*

If one reads these statements which we give here, almost literally from the company's pamphlet, one is amazed to think how any other system but the charcoal system, especially how any system which presupposes the existence and use of sewers, is able to hold its head up.

But not only do other methods hold up their heads, but they, in their turn, exclude the practicability of any but their own systems. What is a plain man, say a householder, to do who would like to form an opinion as to what system of closet he should choose for his house (of course, in towns the choice would practically be made for him by the town authorities, but before such

[1] We follow in this enumeration the small pamphlet distributed in the Exhibition.



MILBURN'S DRYING MACHINE.

is made, he could indirectly influence the choice) in midst of such varied statements?

The best thing he could do is to listen to the opinion of persons who are quite unconnected with either company's having for their object the utilization of sewage, or town authorities who, by some already existing system, are bound to be influenced in their judgments. We shall, further on, quote some such independent opinions.

Another dry closet system well represented at the International Exhibition is that of the Carbon Fertilizer Company. Here, too, as with the above-described company, the material employed for deodorizing the contents of closets, for filtering sewage, &c., is charcoal, but the raw material used for the production of the latter is seaweed. It was first proposed, several years ago, by Mr. Stanford, Glasgow, who later modified the proposition, to the effect that charcoal which had already been used for deodorizing—in other words, which had been mixed with night-soil—should again be carbonized, and afterwards employed for deodorizing purposes, in order to produce a rich manure. This twice-calcined charcoal is termed X coal.

In connection with this mode of utilizing seaweed, we may mention that a ready method of advantageously employing seaweed so as to convert it speedily into valuable manure, consists in laying it in a trench, in successive layers, with unslacked lime between, and then covering the whole with earth. The mass will be rapidly converted into an excellent manure, and the additional percentage of lime will also have its importance in the economy of the farm.

The working of such carbon closets may be understood from the following description by Mr. Stanford:—

"The house may have a closet on each floor—say three, or even four; these are arranged one over the other. Each draws on the same supply of charcoal at the top of the house; the contents of the closet are allowed to fall through a 12-inch thin galvanized iron pipe into a water-tight cemented cesspit in the basement of the house. The charcoal reservoir is filled and the cesspit emptied by the scavenger once a year, the whole process being quite external to the house. The urine is emptied into a simple earthenware urinal in the closet on each floor, and it falls through a lead pipe direct into the pit, where there is always sufficient excess of charcoal to perfectly absorb it. The total absence of all odour is most remarkable. No water-closet can be compared to it. The quantity to be removed is reduced to less than twice the weight of the total excreta, and when removed, an ordinary observer would scarcely know it from the original charcoal employed. The next step in the process is to remove it to the chemical works, where it is re-burned in iron retorts, the ammonia distilled off, and the charcoal returned to the householder. In small villages, one of the retorts at the gas-works will get through a large quantity, and the ammonia will add to the value of the gas-liquor. There is a constant increase of charcoal obtained from the excreta itself; this is an animal charcoal similar to that from bones; it contains the whole of the phosphates and the potash, and with the ammonia is valuable for manure."

Of the two wet-system companies we shall first review the process of the Phosphate Sewage Company. This process, patented by Messrs. Forbes and Astley, consists in precipitating all suspended matter in sewage by phosphate of alumina. It has been for some three or four years past in operation on a large scale on the Lodge Farm, near Barking. The mode of working it is as follows:—The alumina phosphate—a mineral found in England, but chiefly imported from the West Indies—is reduced by grinding to a fine powder, mixed with sulphuric

acid, and the pasty mass formed, after being diluted with water, and kept from settling by a revolving stirrer, is run by driblets at a time into a trough about 2½ ft. wide and 1 ft. deep, along which the raw sewage flows. The trough makes a circuit of considerable length, for the purpose of allowing the current to effect an intimate admixture of the liquid chemical with the dark, quickly-running stream of sewage. At a distance off, perhaps 200 ft. from its commencement, the stream receives a small supply of milk of lime, poured in from a mixing place; and then, well churned by its outward flow, the sewage, after passing through about another 200 ft. length of trough, enters the first settling tank. Here, entering gently by a spreading mouth, it becomes quiescent, and the precipitation proceeds rapidly. The action is thus described. The milk of lime precipitates the whole of the alumina, phosphoric acid, and oxide of iron previously held in solution in the sulphuric acid in the form of a flocculent mass of a density very little superior to that of water; and this, in its consequent gradual descent through the body of the sewage in which it is formed, carries down mechanically the whole of the suspended matter, at the same time exerting a chemical action upon the organic impurities contained in the sewage. Clear, effluent water pours in a thin stream over the edge of the tank at its further end; but by means of compartments, it is certain that very much less than the present tank area would suffice. The continuous simple process goes on for a week or a fortnight, until a layer of slime, about 3 ft. in depth, has accumulated on the bottom of the cemented brick tank, which is made with sloping sides; the supernatant water is drawn off, and the semi-fluid mass is then run out at one end, urged by a man who goes in with long boots and armed with a squeeze. The clearance takes only about half an hour, and there is very little, if any, offensive smell. Raised by a chain pump, the black stuff passes along iron spouts to one of the open-air square drying beds, where, lying in a layer about 1½ ft. deep, it slowly dries till it becomes but a few inches thick, and is shovelled out in slightly moist, crumbly, grey pieces, for sale as manure, or for improvement with sulphuric acid, and manufactured into a dry powder, to be sent out in bags. Throughout the whole of the process no really offensive smell is perceptible.

The effluent waters are used for irrigating, for they are too rich in organic matter to be allowed to run into a clear river. Of course this compels one to ask, why not conduct the raw sewage itself on the fields, without first going to all the expenses of the precipitation process? The answer, that the manure produced sells at a good price, should suggest the thought that the raw sewage ought to sell at a lesser price and still give to the land most of the valuable constituents which it requires. The whole of the labour expenses in the precipitation process is simply thrown away.

The drying of the sludge is not always effected through exposure to the air; the use of drying furnaces is becoming more and more general. A drying machine, exhibited at present at South Kensington, seems peculiarly advantageous for such purposes, as well as for drying other kinds of manures. The machine (see diagram on p. 37) consists of a bed or floor formed of iron plates, which are heated by a fire placed under the wet or feeding end. The fire is covered by a fire-brick arch, which terminates in a double bridge, in which are suitable openings to allow the flame to pass through, and thence under the iron drying floor. These bridges assist in consuming the smoke, and also in distributing the hot air evenly under the drying floor. Covering the fire with the brick arch prevents any excess of heat playing upon the floor and consequent damage to the manure. Over the bed is placed a frame (extending nearly the length of the floor), to which is fixed a series of transverse bars, the edges of which rest evenly on the floor and act as *scrapers*. Between the scrapers, and fixed to the movable frame, is another series of transverse bars, which serve as *pulverizers;* they are fixed above the bed or floor, but do not touch it; for instance, at or near the wet end they do not approach nearer to the plate than 1½ in., and each successive bar comes down closer until the last one at the delivery or dry end almost touches the plate. As the manure passes over the floor, these pulverizers break it up, and as it dries finally reduce it to powder. The form of these pulverizers is varied according to the materials to be operated upon, and in some cases revolving stirrers, provided with teeth and mounted on the frame, are employed to further assist in the disintegration. A reciprocating motion is given to the frame by means of cranks and connecting rods. As the frame moves slowly to and fro, the transverse bars scrape the whole of the bed, keep the material in constant motion, prevent its caking on the iron plates, and gradually deliver it from the machine in its dried state.

Friction rollers, which are attached to the frame, pass over and under a series of lever bars or inclined planes mounted at each side of the machine. These inclined planes are adjusted by set screws, and are made to give the desired lift to the movable frame at its backward movement, when the scrapers pass over a portion of the deposit, and at the return stroke each scraper passes a portion on to the next scraper, and thus the manure travels the length of the plate until it comes off at the end dried and pulverized.

The hot air from the fire, after passing *under* the floor, returns *over* it, and along with the vapour arising from the drying process, is carried away by a chimney over the feed end of the machine; or when a number of machines are used, the vapours may all be carried away by one chimney, fixed at any convenient place. In some cases, the waste heat from a furnace may be conducted under the drying bed or floor, and utilized in lieu of having a separate fire. The machine is designed and executed by Messrs. Milburn and Co.

The second of the precipitation processes shown at the International Exhibition is that patented by Major-General Scott, and distinguished from all other processes for the utilization of the sewage by aiming, not at the production of manure, but of building cement. The cost of this does not exceed that of Portland cement prepared in the usual manner, and the offensive nature of the fæcal matter is completely destroyed. The process consists in mixing with the sewage quantities of lime and clay, the former ingredient combining with the carbonic acid of the fæcal matter to form carbonate of lime, which is precipitated with the other solid ingredients in the form of an impalpable powder. The lime and clay are thrown into the main sewer some little distance before the outlet, so as to insure a more complete incorporation of the different matters, while, at the same time, destroying the slimy, glutinous character of the sewage, and keeping the drain free from the festering and putrefying deposit which otherwise tends to choke it. The clay and the lime do not merely facilitate the deposition of solid matter, but, as is well known, they tend to purify the supernatant water. As lime and clay are the chief constituents of those limestones which, on calcination, yield the best hydraulic limes and cements, it is claimed for this process that there is a sufficient gain of cement-making material abstracted from the sewage to make the operation profitable, independently of the advantages secured by thus deodorizing and defæcating the excrementitious matters of towns, which must otherwise be disposed of in a manner more or less prejudicial to health, and very often at great expense.

The success of the new process depends in no small degree on the fact that the precipitated matter supplies to a considerable extent the fuel necessary for the burning operation. The sewage being allowed to settle in tanks and the supernatant water drawn off, it is found to be deodorized, and may be exposed to the drying action of the air for an indefinite period. It is then dried on tiles, and calcined in the ordinary manner. The fæcal matters, when dried and distilled, yield large quantities of inflammable gases, and readily furnish a most intense heat.

The working of the process as shown at the Exhibition (and most courteously explained by the man who executes it) differs from the above described in that the lime and clay are first mixed with clean water (or water that is derived from sewage previously treated with lime and clay), and the sludge thus obtained passed in a thin stream into sewage.

But we are informed that General Scott has further improved his manufacture of cement by introducing the sludge into a pug mill of novel construction, having its containing walls and bottom formed of a material which will permit the filtration of water, and its axle and arms hollow, and covered like the sides with a material which will allow the water to be drawn through it by suction or forced through it by pressure. The arms are arranged to act with downward and outward pressure, and the containing walls of the pug mill are sometimes surrounded with an outward casing, so as to allow exhaustion of the contained air to take place, and the water which flows through the filtering medium to be removed. In place of the pug mill a horizontal or inclined cylinder of analogous construction may be employed, and will produce precisely the same result. On leaving the pug mill the sludge, deprived more or less of its water, is introduced into a trough or receptacle (having a perforated bottom) where the sludge can be intersected or divided by means of walls or intervening columns, and passages formed of some filtering medium such as town ashes, old mortar, burnt ballast, broken bricks, oyster shells, gas lime, or other refuse, suitable as ingredients of mortar; or bones, shoddy, tan, or other refuse suitable for manure may be used as the filtering medium. By this means the remainder of the superfluous water will be allowed to pass away from the sludge. On the top of the contents of the trough lime, plaster of Paris, green vitriol, or other deodorants are

sometimes put, depending on the intended application of the dried sludge.

The bottom of the trough may be arranged to allow exhaustion to take place beneath it, and the pressure of the atmosphere to be brought upon the sludge, so as to force the water through the filtering medium.

We have said above how necessary it is for any one not intimately acquainted with the sewage question to be able to turn to a quarter where impartial and independent opinion may be got on everything connected with that question. Happily we know that the British Association has for several years past given very great attention to the question, how to deal with sewage. And the deliberate opinion of the committee appointed to inquire into and report upon the matter is: that at present the water-system is the only one that is capable of being generally employed, and especially so for so gigantic a complex of dwellings as London, and that the simplest and most profitable way of disposing of the sewage is to conduct it upon the fields and irrigate these with it. The water which leaves such irrigation fields has been found clean and pure enough to be allowed to enter the nearest river, and the benefit which the ground derives from being manured with sewage is equal to that from the best manures in the market.

The one, and only one, of the objections raised against the water-system which cannot be denied, is its proportionate high price as compared with the carbon system (the dry-earth system, as well as *all* precipitation methods, cannot even be taken into the range of comparison!); but would any man seriously propose the carbon-system for such a place as London? Assuming—by a great stretch of the imagination—such a possibility as the establishing of kilns, furnaces, &c., sufficient in number to supply the Babylon of the West with charcoal, of whatever kind—street-sweeping charcoal, sea-weed charcoal, or X charcoal, what would be the consequences if by some accident the supply of this coal to the houses was stopped for a few days? But apart from such a consideration, we are convinced that a dry-closet is not to the taste of a civilized Englishman, and will therefore never be admitted into houses that make any pretence to comfort and scrupulous cleanliness.

There are various other processes purporting to deal with sewage or with excreta directly, represented at the South Kensington Exhibition; but as we merely intended to make some brief remarks on this important question, and not by any means to treat of it exhaustively, we have restricted ourselves to only citing the cases described in this article.

THE SCREW RUDDER.

By V. Lutschaunig, Professor of Naval Architecture at the Royal Academy of Trieste.

THE idea of swivelling the propeller of a ship, in order to make it serve also for the purpose of steering, dates as far back as the year 1862; but so great are the difficulties connected with its practical execution, that an application to large vessels becomes utterly impracticable. It must, indeed, appear at first sight that it would be extremely imprudent to hang a mechanism of such vital importance as the propeller of a ship on a movable joint, and to transfer the thrust-bearings to inaccessible positions outside the vessel. The steering contrivance which I now propose, surmounts all these difficulties in a very simple manner. The main or driving propeller of the vessel remains perfectly unaltered, and a small swivelling screw, just of sufficient size to answer the steering purposes, is fitted abaft it, precisely in the centre of the rudder-blade itself, where, by the nature of its action, which is always identical with that of the rudder, it greatly contributes to increase the steering power. The shaft of the steering screw turns round the vertical axis of the pintles, or in a balance rudder round the corresponding rudder axis. I have, however, only taken the latter form of rudder into consideration, in the way of adopting steering screws to ships already existing—for with my contrivance balance rudders become perfectly superfluous—and I consider a usual rudder capable of being shipped and unshipped together with the steering screw in the old-fashioned manner preferable under all respects.

In the model which I have constructed, the joint at the pintles is formed by three bevel wheels. I have found that the use of such wheels for similar purposes answers very well. On a crane pontoon, driven by a small swivelling screw, which has been in constant use for eight or nine years in the Arsenal of Pola, these mechanisms work to great satisfaction. Arranged in this manner, the steering screw revolves in the opposite direction to that of the driving screw, so that the two propellers must of necessity be right and left handed. The bending back of the blades of the steering screw has been done with the view of preventing the whirl of water which it produces from coming into contact with the main propeller.

As for the principal advantages which this steering contrivance affords, they may be summed up as follows: 1st.—Great increase of steering power, produced by the combined action of the steering screw and the rudder blade. 2nd.—The possibility of turning the vessel from her position of rest with the first revolutions of the engines. 3rd.—Nearly equal facility in steering when going astern as when going ahead. It is well known that the steering of screw ships when they are going astern is very uncertain. 4th.—A partial elimination of the tendency of steering better one way than another. This will be in consequence of the two screws revolving in opposite directions. 5th.—When the ship is under canvas the screw rudder acts precisely as the usual one. If desired it can, however, be also disconnected by a slight suspension of the whole steering apparatus. 6th.—The rudder may be shipped and unshipped while the vessel is afloat. 7th.—Screw rudders might eventually be kept on board as fighting rudders, keeping a plain rudder in place for ordinary navigation. —*Discussion.* Mr. J. Scott Russell was not sure that for very small war-ships wanted to manœuvre with enormous rapidity, he would not be tempted to try this form of rudder. Mr. Curtis' plan had been tried under the auspices of the Admiralty, and he understood had answered tolerably well. It had not been introduced, for there were probably difficulties in the way, and on a very large scale the difficulties would, he was afraid, become very great. There was a good deal of elegance in the idea, but whether it was worth the trouble was another question. On the whole, the problem was a pretty one, and so was the solution; but he did not like the toothed wheels. In a small vessel, however, he saw no difficulty in putting the whole screw into the rudder. Mr. C. W. Merrifield pointed out that Mr. Lutschaunig had really successfully put the whole screw into the rudder on a small though somewhat special scale. Mr. Willson referred to a similar adaptation which had been found to work remarkably well on the Erie Canal. He thought the steering propeller could be turned to most efficient account on canals, but, if applied to lake or ocean vessels, would prove a failure. Mr. J. Fortescue Hannery said the principle involved in the proposal before the meeting was by no means a new one, and that he should be very apprehensive indeed in fitting such an apparatus to any sea-going ship, even if it proved able to increase the manœuvring power of the vessel.

A FEW NOTES ON MINES AND MINING IN HUNGARY.

(*Continued from "Practical Magazine,"* No. 14, 1874.)

THE process of cupellation[1] depends on the property possessed by lead of becoming oxidized when strongly heated, and at the same time exposed to the air; whilst the silver with which it is mixed is not so affected, and consequently becomes gradually concentrated in that portion of the lead which still remains in the metallic state. It results, from this difference in the behaviour of the two metals, that, when the operation has been continued for a sufficient length of time, the lead becomes entirely oxidized, whilst the silver remains in the metallic form. In order that the oxidation of the lead should proceed rapidly, and without interruption, it is necessary that the temperature to which the alloy is subjected should be sufficiently high to cause the fusion of the litharge produced. The surface of the alloy naturally assumes a convex form, and the fused oxide of lead flows into the annular space existing between the edges of the metallic bath and the surface of the vessel in which it is contained. If, therefore, a depression be made in the edge of the containing vessel, so as to form a channel, the level of which can from time to time be lowered by scraping the bottom by means of a pointed iron bar, the whole of the litharge may be thus drawn off without the escape of any of the unoxidized argentiferous lead.

The furnace employed for this purpose in the Hungarian

[1] We follow in this description of the process of cupellation the source we have indicated in our former paper.

mining districts, and, indeed, commonly on the continent of Europe, where the lead to be operated on is often subjected to cupellation without any preliminary concentration of the silver, is a reverberatory furnace, consisting of a circular hearth from 9 to 10 ft. in diameter, sloping from all sides towards the centre, built of bricks, set on edge on a layer of broken slags. On this is laid a bed of marl, which is firmly beaten in, when in a damp state, and renewed after each operation. This bed of marl, in point of fact, constitutes the cupel, which is heated by means of faggots of brushwood burnt in the fire-place. The roof of the furnace consists of a sheet-iron dome, which may be suspended by chains from a crane, by which it can be removed and again placed in its position over the cupel. This dome is internally plastered with clay.

The cupelling furnace has five openings: one through which the flames from the grate enters the hearth; two through which the nozzles pass supplying the blasts to the surface of the metallic bath, for the purpose of oxidizing the lead, and which also assists in carrying the resulting litharge towards the annular space before referred to; the fourth aperture is employed for the introduction of the discs of lead to be cupelled, and the fifth is that through which the fused litharge makes its escape from the furnace. At the commencement of the operation this last opening is closed by the edge of the layer of marl; but as the cupellation proceeds, it is from time to time cut down so as to keep the channel constantly at the level of the metallic bath. The litharge thus flowing from the apparatus accumulates on the floor of the smelting house, where it solidifies, and from whence it is removed as may be found convenient.

Before commencing a cupellation, it is necessary to prepare a cupel; and for this purpose, after lifting the iron dome, the old cupel, which has become thoroughly impregnated with litharge, is broken up and removed, in order that it may be passed through the blast furnace. The brick bottom of the apparatus is now moistened with water, and successive layers of firmly-ground marl are well beaten in whilst in a somewhat damp state. The iron covering is replaced when the cupel has become sufficiently dry, and all the joints are well secured by luting them with clay.

The furnace is now charged with lead (quantity varying from 4 to 8 tons), which to prevent injury to the bottom is laid on a bed of straw; the fire is lighted and the metal rapidly begins to melt. As soon as the fusion of the discs is completed, the bellows are slowly set in motion, and the surface of the bath becomes covered with a dark coloured powder, consisting of oxide of lead, associated with various impurities. These pulverulent matters, the first of which are known as *Abzug*, and those which follow as *Abstrich*, do not enter into fusion; but the refiner throws now and then a shovelful of coal-dust on the surface of the bath, and, by the aid of a billet of wood, fixed crosswise on the end of an iron bar, draws the impure oxides towards the hole through which the litharge escapes, and finally on to the floor of the works. After the expiration of a short time, fused litharge begins to make its appearance; but that at first formed, being impure, from the presence of other oxides, is usually laid aside, and not mixed with the purer descriptions which soon follow; these are generally sold for glass-making and other purposes, in preference to being again reduced to the metallic state. The litharge produced during the last period of the cupellation invariably contains a considerable amount of silver, and, after being reduced to the metallic state, forms a portion of the charge worked in a subsequent operation.

The blast is now slightly increased, and the oxidation proceeds rapidly; small flaps or valves being frequently fitted to the ends of the nozzles, for the purpose of checking its strength and distributing it more evenly over the surface of the fused metal. The operation is continued in this way until almost the whole of the lead has been converted into oxide; and the silver, retaining only traces of that metal, remains in the vessel, in the form of a metallic cake.

At the moment the oxidation of lead entirely ceases, a phenomenon known as the *brightening* takes place, and the operation is then known to be terminated. During the whole period of cupellation the metallic bath is observed to present a more brilliant appearance than the brickwork of the furnace itself, and its temperature is in reality greater, since it not only participates in the heat developed by the combustion of the fuel employed, but also absorbs nearly the whole of that resulting from the oxidation of the portion of lead which is being constantly converted into litharge. As soon as the oxidation of the lead ceases, this source of heat is at once withdrawn, and the temperature of the bath of metallic silver rapidly descends to that of the brickwork of the furnace; losing at the same time the brilliancy of appearance which it before possessed.

On the other hand, at the instant the last portions of lead become oxidized, an extremely thin pellicle of litharge remains on the surface of the metal, which, rapidly decreasing, exhibits a series of brilliant prismatic colours. This exceedingly thin film of fused litharge finally disappears, leaving the surface of the metal uncovered. These successive, rapidly changing phenomena are called by the Germans the *Blicken*, and by the French the *éclair*.

As soon as the operation is thus perceived to have terminated, the refiner throws water into the hearth, and removes the solidified cake of silver, which usually still retains a sufficient amount of lead to render its further purification necessary.

In some establishments, however, where the marl of which the cupel is composed is of good quality, the process of refining is conducted in the same apparatus. For this purpose the blast is continued for fifteen or twenty minutes after the appearance of the phenomena above described, and some small billets of wood, which are introduced through the litharge door, are kept burning over the surface of the metal. The plate thus obtained contains about 950 parts of silver in 1,000.

The amount of silver resulting from each operation manifestly depends on the weight and richness of the lead operated on; and at Kremnitz a charge, consisting of about four or four and a half tons of auriferous silver lead, used to produce from 1,900 to 2,800 oz. of silver, containing a certain proportion of gold. We believe the amount has in late years been somewhat less.

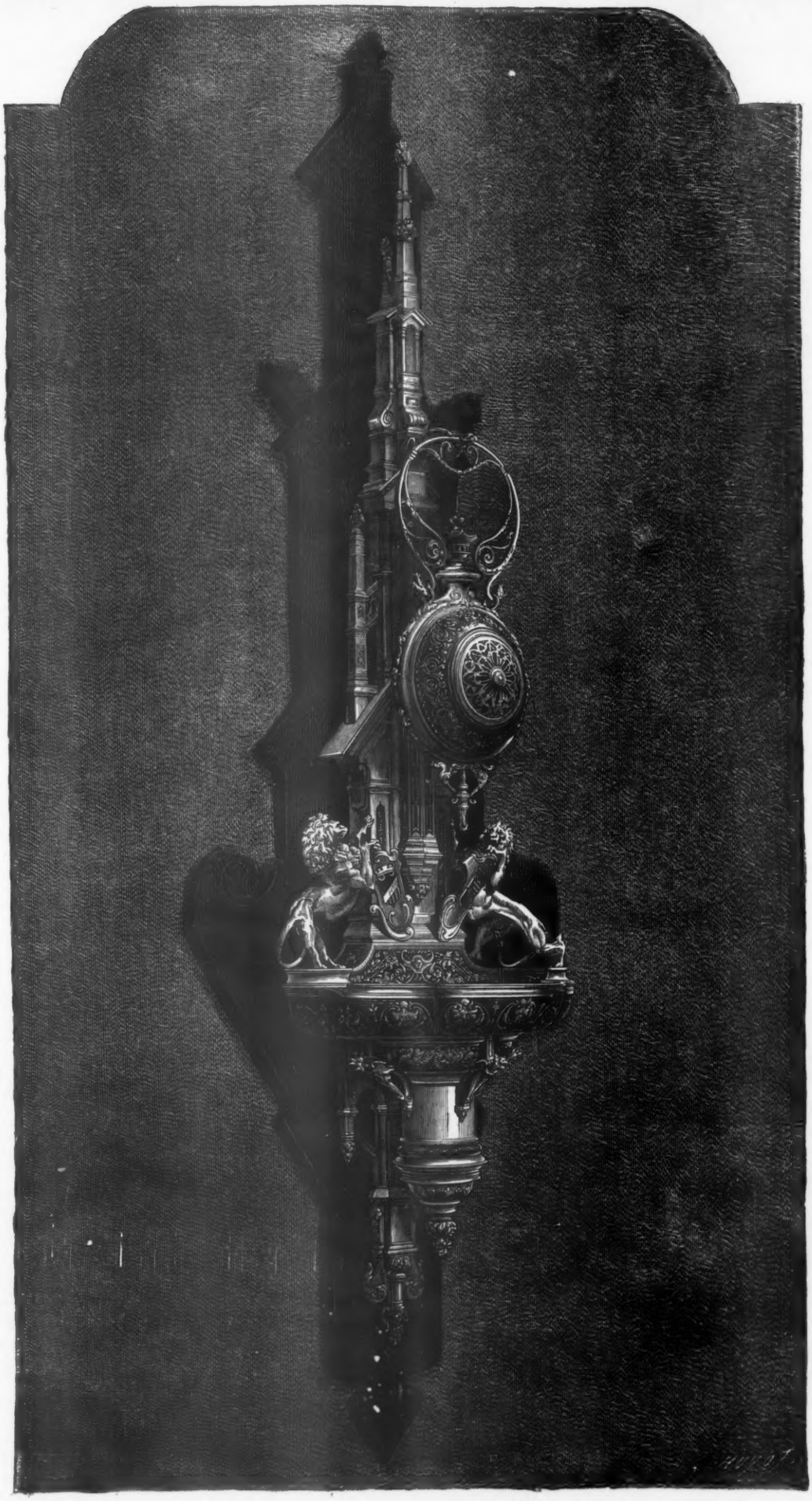
The cupelling furnaces are not always provided with chimneys, but are more often placed under a large hood of masonry, which serves to carry off the smoke escaping from the charging hole and other apertures. Each operation, including the time necessary for preparing the cupel, occupies about thirty hours, and is attended with a loss of lead amounting to from 10 to 12 per cent. of the weight of metal subjected to cupellation. In some localities, coal is the fuel employed in furnaces of this description; but in the districts of Kremnitz and Schemnitz they are restricted to charcoal, and in some cases wood itself is employed. The two last kinds of fuel certainly afford a clear and more oxidizing flame, and can be managed with greater facility.

The final refining of the silver above alluded to is frequently effected in a reverberatory furnace, of which the bottom is composed of bone ash, tightly rammed, whilst in a damp state, into an iron ring, and afterwards so hollowed out as to contain the bath of fused metal. The cupel, which must be thoroughly dry, and ought therefore to be prepared some time beforehand, is, whilst the furnace is still cold, so supported on bricks against abutments prepared for that purpose, as to form the bottom of the apparatus. It is charged with about 1 cwt. of the impure silver to be operated on, and the firing is continued until a bright red heat has been attained; the silver, which has by this time become fused, being exposed to the oxidizing influences of the flame. In this way the lead contained in the alloy becomes oxidized, and the resulting litharge is absorbed by the cupel, of which the temperature is sustained until the oxidation of all but the last traces of lead has been produced. When this point has been attained, the surfaces of the fused metal becomes exceedingly brilliant, and reflects, as in a mirror, all the irregularities of the interior of the crown.

The bottom of the cupel is now pierced by a pointed iron bar, and the silver is run out into moulds, previously heated on a ledge of the furnace. In order to prevent the spirting, or "vegetation" of the bars, they are covered, whilst cooling, by a piece of dry wood, kept down by a weight; and in case any irregularities making their appearance on the surface of the ingots, they are subsequently removed by hammering. This operation occupies altogether from four to five hours, and the resulting bars usually contain from 997 to 998 parts of silver in 1,000 parts of alloy. The actual loss of silver is almost inappreciable; but the diminution in weight experienced on the crude metal from the cupelling surface is from $2\frac{1}{2}$ to 5 per cent.

We have brought to a close with these lines that portion of the Notes on Mining in Hungary which relates to the production of gold and silver in the well-known ancient mining districts of Schemnitz and its neighbourhood. We propose in our next communication to treat of the mines in the Banat, the south-eastern part of Hungary.

(*To be continued.*)



GEMS OF INDUSTRIAL ART.—LAVABO, IN THE RENAISSANCE STYLE, BY MARCHAND.
(⅓ *of actual size.*)

SULZER'S NEW SYSTEM OF VALVE GEAR FOR STEAM-ENGINES.

By Gisbert Kapp,

Engineer in the Machine Factory at Augsburg.

A NEW system of steam-engines has recently been adopted, which already promises, only a very few years from its first appearance, from the general recognition it has found, to supersede the system hitherto in use.

This was first introduced into practice by the Brothers Sulzer, of Winterthur, and is distinguished from the previous modes of construction by the steam being distributed, not by a slide valve, but by four valves of a different kind.

Four valves are fixed to the horizontal cylinder, two of which serve for the introduction of steam, and two for exhaust valves; the arrangement being such that the introducing valves are placed at the upper ends of the cylinder, while the exhaust valves are opposite to these at the bottom of the cylinder.

Distribution by equilibrium valves and gear of this description has this material advantage over the other method by slide valves, that the opening and closing of the steam ports is so quick and perfect, that the principal condition of good regulation (that is, the least amount of loss of steam) is perfectly fulfilled.

This valve gear has also advantages in a constructive sense. There is smaller space required; inconsiderable cooling surface; expulsion of water direct by the exhaust valves and consequently a saving in stopcocks; the easy regulation of each single valve independently of all the others, and furthermore a simplicity in taking machinery to pieces in case of repairs, &c.

The object of the present remarks is not to enter upon the construction of the valve of the steam-engine, but it is desired to set forth a theory of valve gears founded upon Zeuner's theory of slide valve gear. At the same time it will be attempted, for the sake of easier reference, to adopt as many as possible of the terms used in the old system.

Fig. 1.

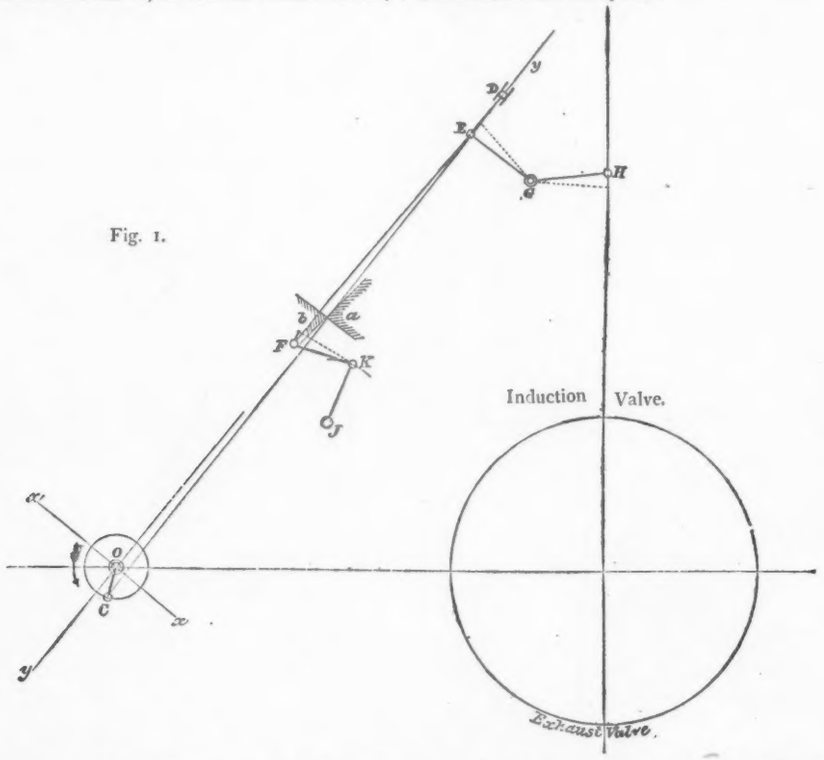


Fig. 1 shows a section or diagram of the steam-cylinder to indicate the place of the valves. These are omitted, as we are only concerned with the law of their motion and not their construction. On the fly-wheel shaft a pair of mitre wheels drive the regulating shaft O, lying parallel and level with the centre or the axis (A) of the cylinder; on this shaft the two excentrics for moving the steam valves and the two irregular plates for moving the exhaust valves are keyed or fixed. These latter offer no further point for theoretical contemplation, and therefore we shall only refer in the following remarks to the mechanism for the inlet of steam.

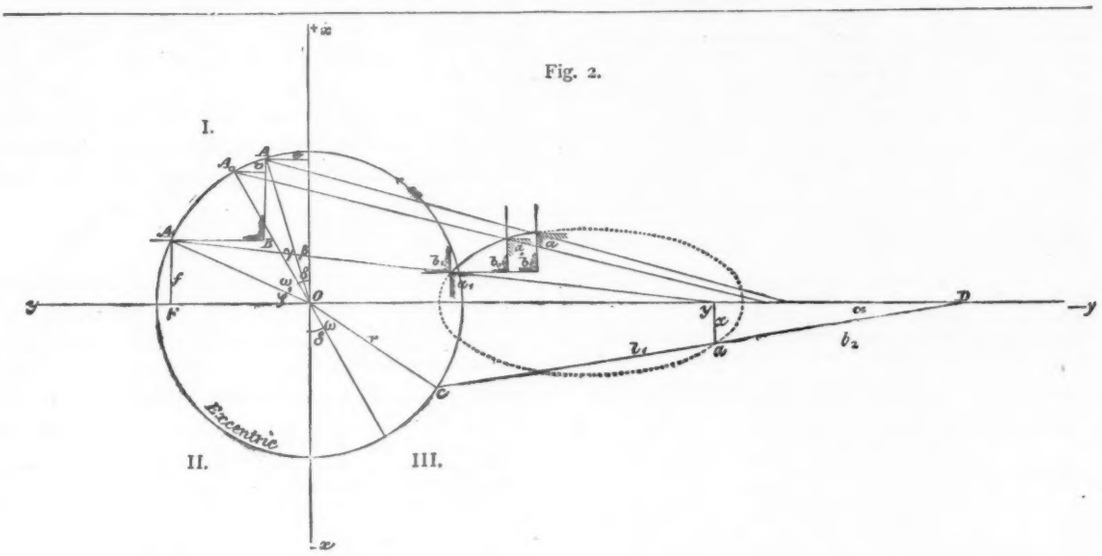
Description of the Mechanical Gear.—This is represented in its mathematical form by fig. 1. O C $= r$ is the excentric radius, $l =$ C D the length of excentric rod, the second end of which, D, slides up and down upon a production of the rod or spindle E F in the direction $o\,y$. In consequence of this arrangement every point in the line C D, and therefore also the foremost edge a of a catch or camb firmly fixed to the excentric rod, describes a peculiar elliptical curve. This curve is shown in fig. 2; the proportions adopted in it are not the same as those existing in constructed machines, the excentric rod being here considerably too short. The proportion $\frac{l}{r}$ has been only adopted for the reason that the curve of the edge a may be distinctly seen.

On the rod F D leading to the valve lever E G H, a second camb b is fixed, which is seized on every revolution of the excentric by a, and carried forward for a certain distance. As b only moves in the direction $o\,y$, while a moves in a curve, the surfaces of the cambs slide one upon the other, and a point of time arrives (equal to the rotary angle of the engine-crank) when these edges overlie each other. In this position (fig. 1) the catch is liberated, the rod E F being brought back to its former place by a spring, and the valve closed.

The position of the catches at their moment of contact, that is the moment when the valve begins to rise, is indicated in fig. 2 by a and b. The excentric radius O C is then in the position O A; if this advances to O A_o the steam-catches are at dead point. Hence $b\,b_o = v$ the raising height of the valve, when the piston is at the beginning of the stroke, i.e., v is the port opening of the valve. When O C reaches O A_1, the foremost edges of the two cambs come into closer contact (designated in fig. 2 by a_1, and b_1,) and the next moment the camb b is liberated, the spring takes effect, steam is cut off, and expansion begins.

The degree of compression is altered by the camb b, in the degree that its foremost edge is brought nearer or farther in the direction $o\,y$, relatively to the axis of the cylinder; in the first case the excentric catch reaches the position O A_2 later, the amount of steam admitted is therefore greater. This forward

Fig. 2.



and backward motion of the catch b is caused by a very slight turn of the rod E F round the point E, the governor acting by the lever J on the point F (fig. 1).

The letters used in the following inquiry may be regarded as representing the following magnitudes :—

R the length of the steam catch,

ω_1 its rotary angle, estimated from the commencement of expansion at the point of rest,

s the angular rate of velocity,

n the number of revolutions per minute,

L the length of the catch rod, E F.

F the area of the piston,

r the excentric radius,

l = C D the length of the excentric rod,

l_1 the distance of the edge a from C,

l_2 the distance of the edge a from D,

ϑ the angle formed by r with the axis X at the moment when the steam catch is at the point of rest ; we shall call this angle, in analogy to those of the slide valve principle—angle of lead or advance,

e the distance between a and b, when the excentric catch stands at the centre point $o\,x$ (corresponding in slide valves to the furthest point of cover),

v the first raising of the valve,

f the distance of the edge b from the axis O Y,

ϕ the angle corresponding to it A, O F (fig. 2), so that $f = r \sin \phi$,

h the extreme altitude of the valve when the steam catch has turned round the angle ω,

h_1 the altitude when the steam catch has turned round ω_1—therefore at the moment of the action of the spring.

FUNDAMENTAL EQUATIONS.—The equation of the curve of the point a, if in the first instance we do not fix any quantities for the sign, is :—

$$y = r \sin (\omega + \vartheta) + l_1 \cos a$$
$$x = l_2 \sin a$$

As $1 \sin a = r \cos (\omega + \vartheta)$,

therefore $\sin a = \frac{r}{l} \cos (\omega + \vartheta)$,

and $\cos a \sqrt{1 - \frac{r^2}{l^2} \cos^2 (\omega + \vartheta)}$,

thence the equation of the curve in question as in relation to the point O is

$$y = r \sin (\omega + \vartheta) + l_1 \sqrt{1 - \frac{r^2}{l^2} \cos^2 (\omega + \vartheta)},$$

$$x = r \cdot \frac{l^2}{1} \cos (\omega + \vartheta).$$

If the magnitude of the roots are developed in a series, and the two first constituents are alone taken, then it would stand thus :—

$$y = r \sin (\omega + \vartheta) + l_1 - \frac{l_1 r^2}{2 l^2} \cdot \cos^2 (\omega + \vartheta),$$

$$x = \frac{r l_2}{l} \cos (\omega + \vartheta).$$

As already remarked, the proportion $\frac{r}{l}$ is very small ; it amounts to about $\frac{1}{20}$. We may, therefore, be allowed to neglect the element $\frac{l_1 r^2}{2 l^2} \cos (\omega + \vartheta)$, as in the other slide valve theory of Zeuner a precisely similar element is neglected. The two equations above then represent an ellipse, the centre of which is about the distance l_1 from the centre O of the regulating lever.

If all the dimensions measured in the direction $o\,x$ be regarded as increased in the proportion $\frac{l}{l^2}$, and a progression of co-ordinates is adopted in the direction $o\,y$ about l_1, the equation of the ellipse above given is resolved into the equation of the circle of the excentric catch. In this circle the motion of the valve may be studied, if it be remembered that the results obtained in the direction $o\,x$ are to be diminished in the proportion $\frac{l^2}{l}$ before they are employed.

$$y = r \sin (\omega + \vartheta)_2 \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$
$$x = r \cos (\omega + \vartheta)_1 \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

From equation (1) is found the height of the valve at a certain crank position, ω_1, $h = r \sin (\omega + \vartheta) - e$.

It should be remarked, that as the motion of the valve is not constant, this equation is only applicable within certain limits, that is to say, only so long as the catches a and b are actually in contact ; hence from $h = 0$ to $h = h_1$,

The value $h = 0$ corresponds (fig. 2) to

$$\omega = -\gamma,$$

and the value $h = h_1$ in our mode of denomination corresponds to $\omega = \omega_1$. Before proceeding any farther it is necessary to make some definite terms. If the excentric has the movement in the direction indicated by the arrow all the distances and angles from O x towards the left and from O y in an upward direction, should be positive. In the quadrant I e and f are therefore positive. If e is negative and f positive, the rise of the valve begins in IV, and the cut-off would take place in I ; if e and f be negative, the rise begins in I V and the cut-off would take place in I I. The quadrant III is not used in the regulation of forward motion.

As before said, the time for the inlet of steam increases with the decreasing of the distance $f f$; the rise of the valve at the beginning of expansion therefore evidently does not remain constant, but is at the maximum when $f = 0$, and decreases according as f increases either towards the positive or negative side. In order to render the loss of pressure of the steam on its passage through the port opening as small as possible, it would plainly be advantageous to make it as large as possible, which is to be done by regarding h as very large, i. e. $f = 0$ as to $\phi = 0$. But this is not always advisable ; especially if the regulators are to act equally well at different degrees of expansion. As a guiding principle it may be assumed, that the port opening in proportion to the height h should at least be proportionate to the rapidity of motion of the crank at the moment of shutting off steam. The magnitude h_1, according to this, should increase on a greater charging of the cylinder. But if, in its normal action, it is already at the

maximum ($\phi = 0$), at a more considerable replenishment, it would become relatively too small, viz., the steam would pass with greater rapidity, and therefore with a greater loss of pressure through the port than was calculated for normal action. If, however, it be desired to utilize the maximum rise of the valve from practical reasons, the gear must be so constructed that this greatest rise of the valve should take place at the most generally occurring degree of expansion. According to this, for the normal action, $\phi = 0$ exactly. It is also desirable that $\phi = 0$ for accuracy of regulation, for then the surfaces of the cambs glide a long way over each other, and the release action still takes place accurately when the edges a and b are even somewhat worn.

The choice of ϕ therefore depends upon which of the advantages are thought most important. It would be out of place to lay down rules here, but each constructor may be left to balance the errors according to the requirements of the engine. It will therefore be assumed in what follows that ϕ is a determined quantity.

From fig. 2 the valve rise would seem to be $h = y - e$ or

$$h = r \sin (\omega + \vartheta) - e \quad . \quad . \quad (3)$$

At the commencement of expansion

$$h_2 = r \sin (\omega + \vartheta) - e \quad . \quad . \quad (4)$$

We also obtain from fig. 2 the equations

$$\left.\begin{aligned} e &= r \sin \vartheta - v \\ e &= r \sin \beta \end{aligned}\right\} \quad . \quad . \quad . \quad (5)$$

$$\vartheta = 90 - \omega_1 - \phi \quad . \quad . \quad . \quad (6)$$

$$\gamma = \vartheta - \beta \quad . \quad . \quad . \quad . \quad . \quad (7)$$

GRAPHICAL REPRESENTATION OF VALVE ACTION.—In order to present the equation (3) graphically, we use at one and the same time the diagrams of Reuleaux and Zeuner. In the construction of these diagrams there is no change to be made as regards the old system of slide valves; we have only to observe, that here, in consequence of the limit of the rise h, only the circles of valve motion lying between the angles $\omega = -\gamma$ and $\omega = \omega_1$ need be taken. Thus, in the diagram of Zeuner, of the valve circle only the completed part need be used; the dotted portion need not be taken into consideration in any way (fig. 4). And the same is to be said of the diagram of Reuleaux (fig. 3). The latter is drawn to half the natural size. If in the figures 3 and 4 a perpendicular is drawn from A_1 to the middle distance of the excentric rod O Y until it is bisected at F, A_1 F = f will give the situation of the foremost edge of the camb b in reference to O Y. To determine the exact distance of this edge b from O Y f must be decreased in the ratio of $\frac{f_2}{f}$.

The distance e is found in fig. 4 as the radius of the circle e and as the perpendicular from A to O x. So in fig. 3, e = AE.

In fig. 4 the opening v is represented by the segment on Oξ between the valve circle and the circle from the radius e; in fig. 3 by the portion marked B B_0.

The maximum rise of the valve h is represented in fig. 3 by the line B A_1.

We have now only to see how the values of h, v, ϑ, e, ϕ are to be determined, in order that the division of the steam should be as favourable as possible.

DETERMINATION OF h_1.—As already remarked, the velocity of steam on passing through the valve should not be very great, or otherwise the tension in the cylinder would be too strongly reduced. The section q for the steam passage, being the diameter and rise of the valve, ought therefore to be made very large. But this, besides other disadvantages in construction, leaves a great and useless space, and therefore it is desirable to take for the velocity of the steam an amount by no means too small—say an accurate mean of from 30 to 50 metres.

Let w_k be the velocity of the piston at the moment of expansion, w_v the steam velocity through the valve, the section of the steam passage will be—

$$q = \frac{F w_k}{w_v} \quad . \quad . \quad . \quad (8)$$

For the velocity of the piston the formula is sufficient as follows—

$$W_k = \varepsilon \frac{R \sin \omega_1}{L \cos \alpha} (L \cos \alpha + R \cos \omega_1),$$

or from fig. 5—

$$\frac{R \sin \omega_1}{L \cos \alpha} = \text{tang } \alpha \text{ and as}$$

$$L \cos \alpha + R \cos \omega_1 = \overline{S_1 O}$$

it further follows that—

$$w = \varepsilon \, . \, \overline{S_1 O} \, . \, \text{tang } \alpha$$

Furthermore—

$$\overline{S_1 O} \text{ tang } \alpha = \overline{O H} \text{ and we have}$$

$$w = \varepsilon \, . \, \overline{O H} \quad . \quad . \quad . \quad (9)$$

If for the angle velocity its equivalent expression $\frac{n \pi}{30}$ be substituted, and, in consequence of the arbitrary nature of our selection of steam-speed, we take the close equivalent $\frac{\pi}{30} = \frac{1}{10}$ we obtain from equation (9)—

$$w_k = \frac{n}{10} \overline{O H} \quad . \quad . \quad . \quad (10)$$

The fraction $\frac{n}{10}$ may be regarded as the tangent of an angle ψ, and from this it is easy to construct the equation (10) in a graphic manner.

Produce the direction of the crank-rod until it cuts Oη in H, draw a straight line from this point H, forming with Oη the angle ψ (tang $\psi = \frac{n}{10}$), and produce the latter until it cuts Oξ at the point W, then $\overline{OW} = w_k$ will be given—the piston-motion sought for at the crank position ω_1.

Having now ascertained w_k, q is to be found from the formula (8), being the greatest section of passage, and from these we can find, as the size and form of the valve are determined by constructive necessities—the value of h_1.

It is also to be remarked that in the present method of determining h_1, it has been tacitly assumed that the expansion is so considerable as to begin even before the velocity of the piston has reached its absolute maximum, which is usually at the time when the valve is half opened. But should exceptionally the supply be greater than $\frac{1}{2}$, h would naturally be h_1 also, regard being had to the absolute maximum velocity of the piston.

DETERMINATION OF v.—This is determined as in the old slide valve theory of Zeuner; it is only necessary to observe that it must be relatively greater. The valves are double-seated conical valves, with somewhat steep surfaces. In consequence of this the section of the opening when the rise is less than the height of the seat is very small, and the angle of lead in the direction of $o y$ must, therefore, be chosen as somewhat large.

SOLUTION OF THE PROBLEMS.—The usual problem presented in practice is as follows:—

The angle ω is given, at which expansion begins, and also the valve rise h, the angle of lead v, and, finally, the angle ϕ.

What is required is the excentric radius, the angular velocity, the distances e and f, and the velocity at which the valve begins to rise.

The angles ϕ and ω_1 being given according to the equation (6), ϑ becomes known.

$$\vartheta = \frac{\pi}{2} - (\omega_1 + \phi).$$

According to equation (4)—

$$h_1 = r \sin (\omega_1 + \vartheta) - e,$$

And according to equation (5)—

$$e = r \sin \vartheta - v.$$

Take from both of these equations e and we have—

$$h_1 - v = r (\sin (\omega_1 + \vartheta) - \sin \vartheta).$$

The eccentricity therefore sought is—

$$r = \frac{h_1 - v}{\sin (\omega_1 + \vartheta) - \sin \vartheta} \quad . \quad . \quad . \quad (11)$$

It will be seen that there always exists for r a positive real value ($h_1 - v$ and ω_1 are naturally always positive), only this value can often become very great. This will occur when $h_1 - v$ is large, ω_1 small, and ϑ is large. It is impossible to change anything at the valve rise h_1, or at the angle of lead ω_1; any change in v can only be very slight, and, therefore, would have a very small influence upon the value of the eccentricity. Should this prove too great, and it become necessary from constructive grounds to diminish it, there is no other resource than to regard the angle ϑ as inconsiderable, as = 0, or even as a negative quantity. This last circumstance is only justified when ω_1 is very great, and, therefore, the inlet velocity of the steam very strong. As it may easily be seen, by equation (11), r will become a minimum when

$$\vartheta = -\frac{\omega_1}{2}.$$

This value of ϑ, according to equation (6), corresponds to the value of ϕ.

$$\phi = \frac{\pi}{2} = \frac{\omega_1}{2}.$$

On the proposition of this problem ϕ was regarded as prescribed (chosen); if the magnitude r has to be made smaller, ϕ

Fig. 3 (Reuleaux).

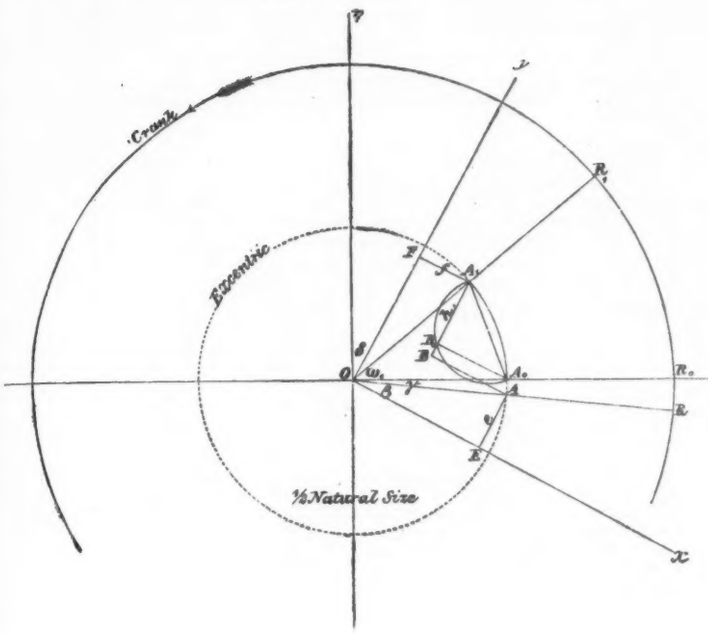
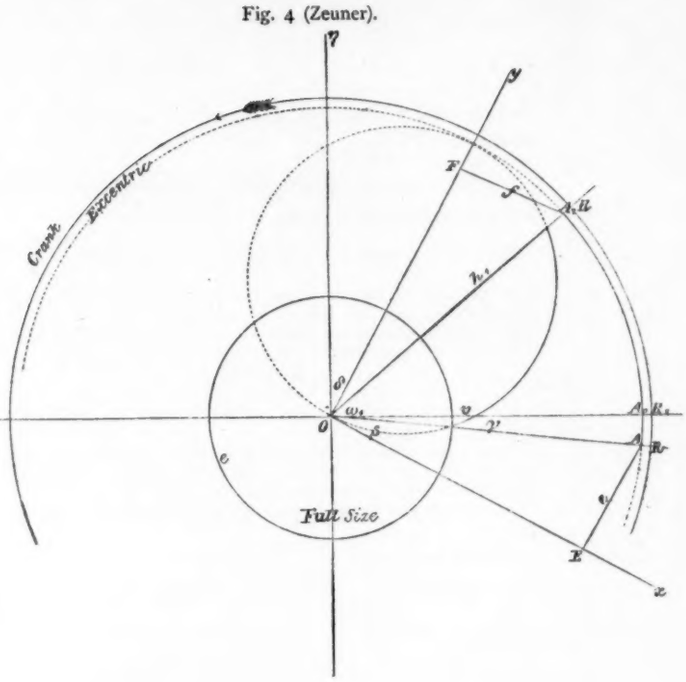


Fig. 4 (Zeuner).



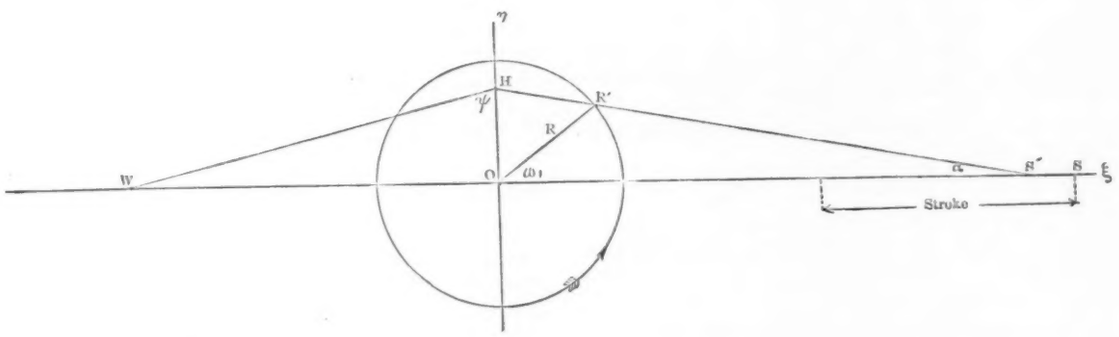


Fig. 6A. (Reuleaux).

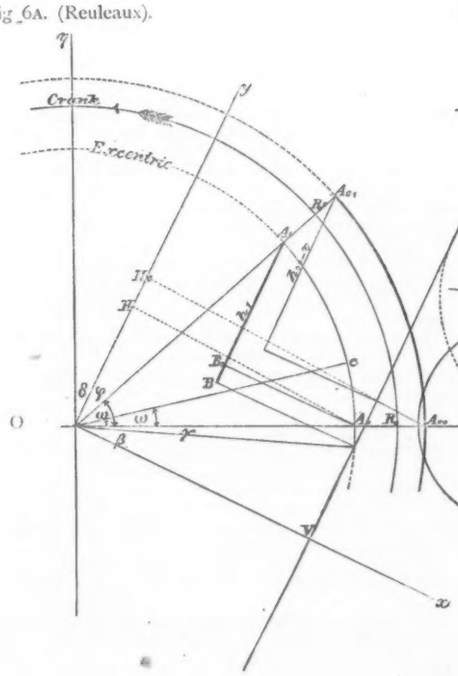
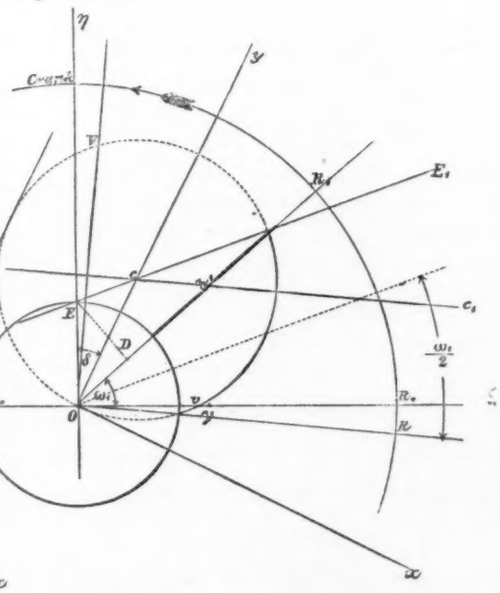


Fig. 6B (Zeuner).



must be otherwise selected, and actually between the boundaries 0 and $\frac{\pi - \omega_1}{2}$.

If ϕ has to be made larger than $\frac{\pi - \omega_1}{2}$, the result would ensue that r would again grow larger.

For practical reasons ϕ must always be smaller than $\frac{\pi - \omega_1}{2}$; first, because in this case the cambs would slide over each other very slightly, and the spring action would be uncertain; and secondly, because the camb b is never actually seized by a, but passes by it. Therefore, as a rule, it stands thus :—

$$\phi < \frac{\pi - \omega_1}{2}.$$

From equation (11) r may be calculated; but it is much better to construct r itself.

If for r a value r_0 be first imagined as accepted, and the diagram be constructed for this, another value for the valve rise would result, which may be designated as h_{01}.

For this rise the equation (11_0) is equally fitted : it is as follows :—

$$r_0 = \sin \frac{h_{01} - v}{(\omega_1 + \vartheta) - \sin \vartheta} \quad . \quad . \quad . \quad (11_0)$$

From the equations (11) and (11_0) it follows that—

$$r : r_0 = h_1 - v : h_{01} - v.$$

This proportion admits of r being easily constructed with the aid of similar triangles.

In fig. 6A (Reuleaux's diagram) for this purpose $h_1 - v$ and $h_{01} - v$ (the latter being obtained from an arbitrary eccentricity r_0) have been inserted from O to O y, so that,—

$$h_1 - v = OH$$
$$h_{01} - v = OH_0.$$

If H_0 be joined with A_{00} by a straight line, and a parallel is drawn through this at H, which bisects $O\xi$ at A_0, A_0 becomes a point of the desired eccentric circle, therefore,—

$$r = OA_0.$$

With the aid of the Zeuner diagram (fig. 6B) r is easily determined graphically.

From equation (4) the following ensues :—

$$h_1 - v = r \sin (\omega_1 + \vartheta) - (e + v)$$

or

$$h_1 - v = r \sin (\omega_1 + \vartheta) - r \sin \vartheta \quad . \quad . \quad (12)$$

Let ξ and η denote the co-ordinates of the centre of the valve circle, so that,—

$$r \sin \vartheta = 2\xi$$
$$r \cos \vartheta = 2\eta$$

then the above equation can also be written in this form :—

$$h_1 - v = 2\xi \cos \omega_1 + 2\eta \sin \omega_1 - 2\xi.$$

If, therefore, the conditions were that the angle ω and the value $h_1 - v$ should be constant, whereas the valve-circle, i. e. its radius, and angle of lead were variable, the centre of this circle would always lie between the straight lines represented by the above equation.

In order to construct this with greater ease, we will bring the equation into another form :—

$$\eta = \frac{1 - \cos \omega_1}{\sin \omega_1} \xi + \frac{h_1 - v}{\sin \omega_1}$$

If we take for the sake of argument $\frac{1 - \cos \omega_1}{\sin \omega_1} = \tan \theta$, then θ would be the angle which the straight line $\xi\eta$ forms with the axis of ξ, and $\frac{1}{2} \frac{h_1 - v}{\sin \omega_1}$ the portion which it divides from the point O towards the axis of η.

From the equation

$$\tan \theta = \frac{1 - \cos \omega_1}{\sin \omega_1}$$

by simple calculation we obtain,—

$$\theta = \frac{\omega_1}{2}.$$

Thus the upright in question can easily be constructed. Fig. 6B.

Produce from O to OR a line $\frac{h_1 - v}{2} = OD$, erect a normal at OR, and determine its point of section E with $O\eta$, then we have :—

$$OE = \tfrac{1}{2} \frac{h_1 - v}{\sin \omega_1}.$$

The upright required passes through the point E, and as it must be parallel to the section of the angle $R_0 OR_1$ it is fully determined.

In all valve circles the centres of which lie upon themselves, that is to be taken, possessing value determined by the selection of ϕ, thus :—

$$\vartheta = \frac{\pi}{2} - (\omega_1 + \phi).$$

In order, therefore, to find the centre point c of the valve circle in question, a line Oy must be drawn through O to $O\eta$ under the angle ϑ, the point of bisection being determined with the line $\overline{EE_1}$. The straight line $\overline{EE_1}$ also shows how the magnitude of the ex-centre radius is altered with the angle. The eccentricity is at a minimum when Oc stands perpendicularly upon $\overline{EE_1}$, therefore $\vartheta = -\frac{\omega_1}{2}$, as it was already calculated by equation (11). With the increase of ϑ the centre-point of the valve-circle passes along the perpendicular EE_1 towards E_1, and theoretically may become equal to ∞. Should r be too large, and from constructive reasons it is desirable to diminish it, the lowest margin for this reduction is naturally to be the same as that already mentioned for the diagram of Reuleaux.

When the cambs a and b meet there is a collision, because the valve and every part of the regulating apparatus is suddenly brought from a condition of rest into that of motion. The stronger the shock, *i.e.* the greater the rapidity of the camb a at the moment of contact with b, the quicker the valve will be raised, and therefore the more favourable it is for the admission of steam. It will therefore be of some interest to consider this rapidity in our contemplation of the diagram.

If in fig. 6A the excentric crank is standing in any position Oc, the steam crank has turned round the angle $\omega = A_0 Oc$, then the measured velocity of the camb a in the direction Oy is expressed by

$$w_y = r\omega \cos (\omega + \vartheta).$$

At the moment of contact however the excentric crank is in OA and $\omega = -\gamma$.

This being added to the above formula, and it being observed that $\vartheta = \beta + \gamma$—the velocity of rise would be

$$w_y = \varepsilon \, . \, r \cos \beta = \varepsilon \, . \, OV.$$

The value assigned to ε above,

$$\varepsilon = \tan \phi = \frac{1}{10} n,$$

it follows that—

$$w_y = \frac{1}{10} n \, . \, \overline{OV}.$$

The number of revolutions n being regarded as constant in one and the same machine, the velocity of rise would be proportional to the distance OV, and we shall only take this into consideration, as we have already given all that is necessary on the construction of w.

If r and s, or what is the same thing, r and e, are altered in the regulation so that (fig. 6A)

$$r \cos \beta = OV = \text{Const.}$$

proportionately that $r^2 - e^2 = OV^2 = \text{Const.}$

we obtain the velocity of rise also as a constant velocity.

The perpendicular at AV relative to its production gives us a means whereby we may compare different regulations (n being regarded as constant) in reference to the rapidity with which the valve is opened. All gear in which the point A lies to the left of this line (therefore between it and the axis y), open the valve much slower, and all gear in which A lies to the right of the perpendicular open it quicker. In the diagram fig. 6B this perpendicular is replaced by a perpendicular line cc_1 drawn through c to OV. If r and e are so changed that the centre point of the valve circle moves upon cc_1, the velocity of rise remains constant. But if it lie under cc_1, therefore between cc_1 and Oξ, it is less, if above cc_1 it is more than in the above-named instance.

The problem under consideration is little altered if instead of giving the moment of opening v the angle γ is given—*i.e.* the position of the steam crank at the instant of contact between the catches or cambs.

From equations (4) and (5) it results that—

$$h_1 = r \sin (\omega_1 + \vartheta) - r \sin \beta.$$

According to equation (7) $\beta = \vartheta - \gamma$ therefore—

$$h_1 = r \sin (\omega_1 + \vartheta) - r \sin (\vartheta - \gamma). \quad . \quad . \quad . \quad . \quad . \quad (13)$$

If this equation be written down in the form—

$$h_1 = r \sin (\omega_1 + \gamma) + (\vartheta - \gamma) - r \sin (\vartheta - \gamma),$$

it will be seen that it corresponds with the form of the equation (12) in the preceding problem,

$$h_1 - v = r \sin (\omega_1 + \vartheta) - r \sin \vartheta.$$

For $h_1 - v$ stands h_1, for ω stands $\omega_1 + \gamma$, and for ϑ stands $\vartheta - \gamma$.

The equation (13) can therefore be obtained from equation (12) if h_1 be substituted for $(h_1 - v)$, and a turn of the axes takes

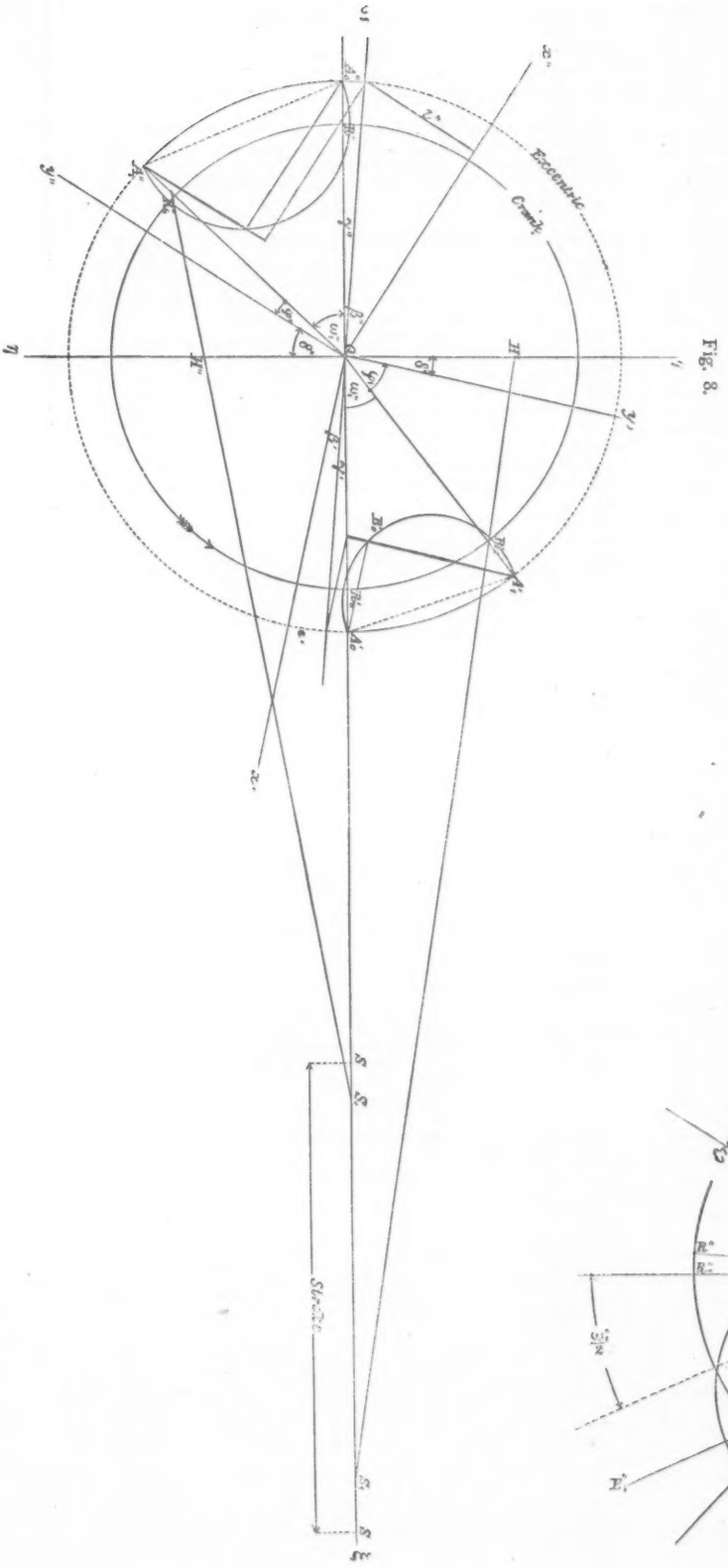


Fig. 8.

Fig. 7.

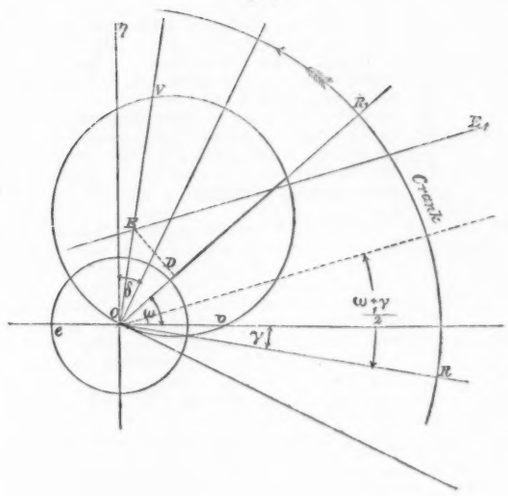
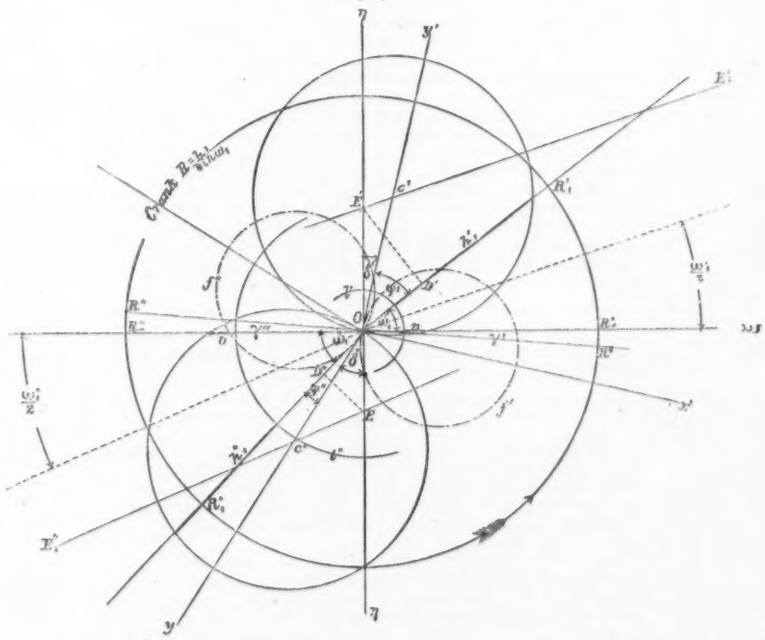


Fig. 9.



place round the angle γ. In consequence of this the construction given in diagram 6B of the former problem only alters in the particular that now (fig. 7) O V is regarded as the η axis, therefore E at the sectional point of O V with the perpendicular drawn in D to $OD = \frac{h_1}{2}$. The line EE_1 is then parallel to the division line of the angle ROR_1.

By different modes of denominating the elements of parts, several more problems might be combined, as in those in which ϕ is considered fixed from the first. But it is unnecessary to enter upon this, as they are of the utmost simplicity, and also from the extreme rarity of their occurrence. We shall however treat in a later part of this paper on one problem, in which ϕ is not taken as determined, but where this selection of ϕ is not regarded as prescribed, but the selection of ϕ is replaced by the necessity that the regulation required to be constructed shall act equally with two different degrees of pressure, as to the angles ω_1 and ω_2.

But we will first examine at greater length the problems solved for one valve, and extend them to the action of two valves; in other words, for the passage and return of the piston. Until now it has always been taken for granted that we had only to do with one valve, and therefore with the known angle ω_1. How this was obtained was quite immaterial in the course of our researches. In order, however, to obtain a full insight into the relations now arising, it is necessary to examine the travel and return of the piston separately.

In the ordinary rod regulator with only one rod, the cut-off of the steam takes place whether the piston is entering or returning, at equal angles of the steam crank. (The angles always to be counted from the point of rest.) In consequence of the connecting-rod not being infinitely long, these equal angles by no means correspond to an equal piston travel during the period of entrance. On the out stroke of the piston, as it approaches the crank, this travel is greater, and on its return less than would be the case were the connecting-rod of infinite length. Hence the engine works harder during the return of the piston, and therefore does more work during the first semicircular turn than during the second.

These disadvantages, inherent in the engine, from this cause, of a smaller equality in action and a less favourable use of materials, are not very great, yet they are sufficient to cause their removal desirable. This is not realizable with a simple slide valve, but with two slide valves it can be done. The valve gear can always be so contrived that the forward and backward travel can at least be equal for one degree of replenishment. By Farcot's system, as every practical man knows, this can be done in all cases by not making the catches or cambs on which the regulator acts symmetrical.

This is not the place to enter further upon this construction, as although it is not always mentioned in the manuals, has been long known in practice, and we are for the present only concerned as to the best means of using them in valve gear.

In the following observations the values occurring when they refer to the out stroke will be marked with one stroke, and those occurring at the out stroke with two, as an index. For example, h'_1 will denote the valve rise for the out stroke, therefore the rise of the valve, V', most distant from the crank, and h_1'' the rise for the nearer valve, V''; ω'_1 the angle during the first half turn, ω_1'' that during the second half turn of the crank, &c.

For the determination of h_1' and h_1'', we assume that the port opening of the valve, in section, would be proportional to the rise.

As, therefore, according to the principle just enunciated, the section of the port, or its equivalent, the distance OH (fig. 5) is proportional to the velocity of the piston, the equation must be—

$$h_1' : h_1'' = O H' : O H''.$$

If then h_1 denote the valve rise under the condition of an infinitely prolonged connecting-rod, and $OH = R \sin \omega_1$, the corresponding section on the axis η, the equation is—

$$\left.\begin{aligned} h_1' : h_1 &= O H' : O H \\ h_1'' : h_1 &= O H'' : O H \end{aligned}\right\} \quad \ldots\ldots\ldots \quad (14)$$

If the regulator for a valve with the condition of an infinite prolonged connecting-rod has been constructed, therefore has been determined for example according to the first series of problems, it is now sought to find how the values found are to be differentiated, in order that the present conditions ω_1', h'_1, ω_1'', and h_1'' may be satisfied.

For practical reasons it does not appear admissible to make the excentric radii of the two valves different, therefore we will retain the eccentricity found for both valves in the solution of the above problem, and content ourselves by causing the engine to work equally by an alteration in the other magnitudes.

The following problem is therefore before us :—

For the construction of the regulator is given—

(1) The eccentricity r; (2) the angle of lead as to ω_1', ω_1''; (3) the valve rise h'_1 proportionate to h_1''; and (4) finally the fore opening v.

The remaining portions are sought, viz., ϑ' as to ϑ'', γ' as to γ'', e' as to e''.

To find the angle ϑ' (ϑ'') may be expressed by the theorem : With a given radius r and angle ω'—the points A_o and A_1 (fig. 3), to find the mean position of the eccentric rod, viz., oy. If A_1 and A_o are joined by a straight line and a semicircle be erected over the distance $A_1 A_o$, the point B_o as $\sphericalangle A_1 B_o A_o = \frac{\pi}{2}$ must lie in the periphery of this semicircle. The distance $A_1 B_o = h_1 - r$ is parallel to oy. From this we obtain a very simple construction for the discovery of the required angle. Describe a semicircle over $A_o A_1$, take the prescribed length $h_1 - v$ with the compasses, fix it at A_1 and cut this semicircle with an arc at the point B_o, and the straight line $A_1 B_o$ will already show the direction of oy. If then oy is drawn from o parallel to $A_1 B_o$ then $\sphericalangle \eta oy = \vartheta$ the angle required. In order to determine the portions yet required, let the length $B_o B = v$ be added to the prolonged lines $A_1 B_o$ and a parallel drawn through B to the axis x, and the sectional point A be determined with the circle of the eccentric crank. The distance A v, the perpendicular distance of the point A from ox, gives the dimension e, and the angle formed by O A enclosing the ξ axis, is γ.

In fig. 8 the construction for the out and in stroke of the piston, i.e. for both the valves, is specially carried out. The magnitude of the eccentric radius r is to be found from fig. 6 constructed for $\frac{1}{8}$ cylinder, an infinitely prolonged connecting-rod being presupposed. The determination of the values h_1' and h_1'' has been shown in the diagram (fig. 8). In order to obtain it in the simplest way, let the valve

$$R = \frac{h_1}{\sin \omega_1}$$

be taken as the radius of the crank circle, instead of the actual length of the crank. We thus find that—

$$h_1 = O H,$$

and in consequence of equation (14)

$$\left.\begin{aligned} h_1' &= O H' \\ h_1'' &= O H'' \end{aligned}\right\} \quad \ldots\ldots\ldots \quad (15).$$

The circle $R R_o R_1$ being described with a semi-diameter $= \frac{h'}{\sin \omega}$, h_1', and h_1'' need not be constructed with the aid of similar triangles, but this maximum rise of the valve can be directly obtained as a section of the connecting-rod at $o\,\eta$.

In the drawing, in order to show the difference of the diagrams for out stroke and in stroke more plainly, and also to save room, $\frac{L}{R} = 4$ was adopted. When the piston reaches the situation S_1, expansion would begin; if, therefore, arcs are drawn from the two points S_1, of the length of the connecting-rod until the circle $R R_o R_1$ is segmented in R_1' and R_1'', then

$$\sphericalangle R_o' O R_1' = \omega_1'$$
$$\sphericalangle R_o'' O R_1'' = \omega_1''.$$

The cylinder pressure being taken as $\frac{1}{8}$, we find for the out and in stroke of the piston

$$S_1 S = \tfrac{1}{8} S S.$$

To find the axis system y' x', and with this the angle

$$\vartheta' = \eta o y',$$

let a semicircle be erected over $A_o' A_1'$, cut this from A_1' with an arc the radius of which is equal to $(O H_1' - v)$ at B_o' and draw a parallel from O, and a perpendicular in the direction of $A_1' B_o'$—these will be the axes x' and y' required. In the same manner find x'' and y''.

Having thus determined the angles ϑ' and ϑ'', the other elements are easily found in the diagrams by direct measurement. In fig. 9, the same problem is solved by the application of the Zeuner diagram. The connecting-rods, as well as the different positions of the piston, are not drawn in, as they only serve to determine the magnitudes $\omega_1' \omega_1''$, $O H_1'$ and $O H_1''$, and these can be ascertained from fig. 8.

For the solution of the problem, let the straight line $E_1 E_1'$ be first constructed; this is the geometrical place of all centres of valve circles giving an equal valve rise h_1'' in constants. As the radius of the valve circle hereto be used is known from fig. 6, its position is already fully determined. If the half of the excentric radius—as given in the fig. 6—be taken with the compass as $\frac{r}{2}$

and the straight line E′ E_1′ be cut through from the point O at c', then c' is the centre point of the valve circle required, therefore

$$\sphericalangle \, O\,c' = \vartheta'$$

the required angle for the out stroke of the piston.

It should be observed that the straight line E′ E_1′ is cut by the arc $\frac{r}{2}$ at two points, and therefore some doubt might arise as to which of these is the sought for centre point of the valve circle. Mathematically speaking, both sectional points of the arc $\frac{r}{2}$ on the straight line E′ E_1′, are centre points of valve circles fulfilling the required conditions; one of these valve circles gives an angle smaller than the angle $\frac{\omega_1}{2}$. We have already mentioned, when we discussed the question of how too great an excentric radius could be reduced, that when ϑ is equal, or even smaller than $\frac{\omega_1}{2}$ the camb b cannot be carried away by the camb b_1, as the outward edges of the cambs alone touch $\left(\vartheta = -\frac{\omega_1}{2}\right)$ or even pass each other $\left(\vartheta < -\frac{\omega_1}{2}\right)$.

Of the two valve circles that one, therefore, is to be taken in which

$$\vartheta' > -\frac{\omega_1'}{2}.$$

By using the straight line E″ E_1″, ϑ'' can be found for the out stroke of the piston, and all the other values can be read simply from the diagram.

According to the prescribed assumption

$$f = r \sin \phi = r \cos (\vartheta + \omega_1).$$

If then a circle with the radius $\frac{r}{2}$, the centre of which is situated at the x axis, be described through O expressions of the formula $r \cos (\omega + \vartheta)$ are graphically represented in the sections of the radii vectores lying between the point of beginning and the periphery, making with O ξ the angle ω. At the commencement of expansion $\omega = \omega_1$, and $\cos (\omega + \vartheta) = \sin \phi$; consequently the length f can be at once measured off in the diagram, as the portion cut off from the above-named circle on the straight line O R. The actual distance of the camb b from oy, as we remarked above in our development of the principal equations, is not f now obtained, but the latter must be diminished in the proportion $\frac{l_2}{l}$. In order to avoid having to make this reduction, we do not draw the circle for the determination of f with the radius $\frac{r}{2}$, but with the radius $\frac{r}{2} \cdot \frac{l_2}{l}$ and observe that the portions now cut off on the radii vectores are the real magnitudes or values of f.

If the pressure in the cylinder changes, therefore, the angle ω_1, then f also changes, as may be seen from the diagram. Should $\omega_1 = 0$, so that the expansion should be so great that no more steam enters the cylinder, then the position will stand thus, $f = \left(\frac{l_2}{l}\right) r \cos \vartheta$. This value is the highest limit of f, i. e. it shows the highest place of the indicator of the regulator. Let ω max denote the largest angle of replenishment occurring in the engine, the part taken from the diagram—

$$f = \frac{l_2}{l} r \cos (\vartheta + \omega \text{ max})$$

will give the lowest limit of the value of f, and also the lowest place of the indicator on the regulator. The difference of these ascertained two extreme values for f will give the whole length of the play of the indicator, so that plenitude may vary between the limits 0 and max. It is assumed that the transference of the motion of the indicator to the camb b, is effected by a number of equal levers; but if this be not the case in the determination of the maximum travel of the indicator, the interrelations of the levers have to be taken into account. In fig. 9, the circles for f as well for the forward as the backward movement of the piston are shown by dotted lines. If then it should happen that the regulation should work in such a manner that at a certain degree of replenishment $\frac{S S_2}{S S}$ in relation to the angles of replenishment ω_1' and ω_1'', the forward and backward expansion is equal, then the distance of the camb b from Oy must for the valve V′ be

$$f' = \left(\frac{l_2}{l}\right) r \cos (\omega_1' + \vartheta')$$

and at the valve V″

$$f'' = \left(\frac{l_2}{l}\right) r \cos (\omega_1'' + \vartheta'').$$

This is done by altering the distance F K (fig. 1) adjustable by screws. In the actual adjustment of the gearing the distance of the camb b from Oy is not determined or regulated by measurement, but only by pushing the piston to the point S_2, when the crank is in the position of ω_1' as to ω_1'', and the distance K F is then carefully increased by the regulating screw until the valve closes. This being done with both valves, the engine works equally in the forward and backward movement. This, however, is only true of this particular degree of replenishment; in all others the forward expansion is not equal to the backward expansion. The regulator acts equally by the regulating rods; in consequence of which, f' and f'' are always increased or diminished in the same proportion.

This alteration implies according to the above equations for f' and f'' a certain change in the angles ω_1' and ω_1'', in $\omega^{2'}$ and ω_2''. Here the angles of replenishment are functions of f_1' and f'''; they ought actually to be, however, functions of the piston-travel during the period of admission. It may be seen that the angles of replenishment cannot satisfy these widely different functions, and hence it is impossible to produce equal backward and forward expansion for all degrees of replenishment. But it may be effected by not transferring the motion of the regulator to the camb b by levers acting equally upon both cambs, but by oval plates, the form of which, as in the old system, is different for each valve, and may be found in the two diagrams.

There does not seem, however, at the present time, any need for this improvement. It is very inconsiderable, and indeed quite valueless, when the requirements for the machine remain equal, and the degree of replenishment changes little. It is sufficient under these circumstances to construct the gearing accurately for the normal degree of replenishment.

CONSIDERATION OF THE PROBLEM OF HOW TO CONSTRUCT SUCH A SYSTEM OF REGULATION THAT IT SHALL ACT AT TWO DEGREES OF REPLENISHMENT ACCURATELY AND WELL.—It has already been said above that the selection of ϕ can be replaced, by stating between what limits variation of replenishment shall exist, and at the same time the condition of equality of action ensured. This is effected when there is a proportion between the maximum and minimum replenishment of the cylinder and the velocities of the piston at the moment of closing. The problem stated above may therefore be mathematically expressed in the following form:—

Given two angles of replenishment ω_{11} and ω_2 and also the corresponding rise of the valve h_1 and h_2; finally the size of the opening v. The other elements are to be found.

In order to solve this problem, it is necessary to make use of the construction given in diagram 6B in a double way, once for the condition ω_{11}, h_1, and v, and again for the condition ω_2, h_2, and v.

The straight line E E_1 was found to be the geometrical place of all centres of valve circles, giving in constant opening and angles of replenishment an equal valve rise. If, therefore, according to the rules given, this E E_1 be constructed first for ω_{11}, h_{11}, and v, and then another G G_1 for ω_2, h_2, and v, in the intersection between E E_1 and G G_1 the centre point of the valve circle sought for will be found. And with this all other parts are fully determined, and may be read off from the diagram.

In practical construction as a rule, the valve circle for the backward movement is considerably smaller than for the forward movement, and it may easily happen that the angle ϑ'' (back movement) may be equal to or smaller than the extreme value $\frac{\omega_1''}{2}$. But as we have already explained, this is unimportant, as no contact between the cambs can take place; and in the majority of cases it will be impossible to make the eccentric radii for the valves V′ and V″ of different sizes. From this it may be seen that the problem in certain cases, at least not in a strict sense, is insoluble; should this be so, there is no other way than to adopt a middle course, and by experiment ascertain those values of r, and of each angle ϑ' and ϑ'' least incoherent with the fixed condition.

SUMMARY OF THE RULES OF CONSTRUCTION.—In order to construct a regulator for a given degree of expansion the following method should be adopted:—

It would be necessary to select,

1. The position ϕ of the excentric radius, at which the catch spring acts;
2. The maximum velocity of the steam on its passage through the valve between the limits 30 to 50 metres.
3. The opening v.

Next, an infinite connecting-rod being assumed, let the piston velocity at the commencement of expansion be constructed, and from this, having due consideration for the shape of the valve, and the steam velocity in it, its lifting power or rise h_1, at the instant before steam is shut off.

This h_1 being known, the assumption of an infinite connecting-rod being continued from the values of h_1, ω_1, and v, the excentric radius ϕ should be determined. Should this prove too great or too small, it can be altered by a subsequent adoption of another ϕ.

Having thus ascertained r, extend the construction to the two valves V′ and V″, having first determined the valve rises h', and h''_1, due regard being had to the finitude of the connecting-rod, and next having constructed the angles ϑ' and ϑ'' in conjunction with the already known magnitudes ω'_1, r, v, and ω''_1, r, v. With these may be found the remaining parts required; ϵ', β', γ', ϕ' as to ϵ'', β'', γ'', ϕ''; and the problem is solved.

K. R. H. M.

ENGINES FOR IRONCLADS.

WHEN the necessity for armouring war ships with iron plates became apparent, it was said that the navy must be entirely reconstructed, but at the time the conviction was forced upon us, it was scarcely imagined that reconstruction in the usual sense of the term, could not be used to define all that had to be done with our navy; the war between plates and guns commenced with horizontal shell firing, and still appears as far as ever from settlement. One thing, Mr. E. J. Reed tells us, is certain, that we must be content to go on building bigger and yet bigger ships if we mean to retain our sea sovereignty. The rapid changes going on in war ship building and arming, bring us face to face with a third section of war ship economy, viz. the steam engines and boilers which are to develop the power requisite to force gigantic floating bodies, such as the new war ship "Inflexible" will exemplify, through the water at the high rates of speed so essential under existing conditions. In considering the type of engine best adapted for large ironclads it may be as well to divide the subject and deal with each section by itself, and then sum the results up into one aggregate. The points essential to engines for war ships are of course that they should be most economical of coal, not so much as a matter of economy of money, but as tending directly to enhance the efficiency of the ship. Much more manœuvring will take place at sea between the war ships of the immediate future than was adopted in Nelson's time, the day for a yard-arm to yard-arm fight is gone by for ever; the principal occupations that ironclads will have as war ships will be as blockaders; it is extremely doubtful that such a vessel as the "Inflexible" will ever be used as a convoy, or indeed whether we shall ever again see a fleet of merchant ships sail down the Channel, under the protection of two or three war ships; in the event of war it will be a question with merchant ships, of sharp captains to keep clear of the enemy, and a clean pair of heels; blockading will be more the fashion, and as a method of damaging the commerce of an enemy a rigid blockade will probably prove more effectual than a system of cruising with a host of "Inflexibles;" it is then evident that the vessel that can remain longest at her station without coaling will be the most efficient, and economy of fuel consequently, if only for this reason, becomes of paramount importance; the ship which runs short of coal before she is relieved will almost certainly fall a prey to an enemy's ship of equal strength, which has the motive power on board her.

The question of the best type of engine for the ironclad of the future is beginning to attract attention from the Government, and one vessel, the "Briton," has been fitted with the compound engine, now fashionable in the mercantile marine. We believe we are right too in stating that compound engines were proposed for the "Inflexible," but had to be abandoned owing to the impossibility of getting the low pressure cylinders made of sufficient size, and the question here again presents itself, what is the best engine for a war ship?—compound or not compound? In order that our non-professional readers may the better appreciate the real bearings of this question, we will explain briefly the principles involved. It is now admitted on all hands that high pressure steam admitted to the cylinder for a small portion of the piston stroke and then left to expand down, is the real method to secure, in a practical way, economy of fuel so far as the engine is concerned. Up to this point engineers agree, and beyond this point unfortunately schism prevails; A, B, and C, while in accord as to the value of expansion, differ as to the best limit for the expansion, and as to the method of practically putting their theories into operation; the chief cause for this schism lies in the extreme difficulty that attends all attempts to gauge with precision, the exact economy of fuel obtained with the various grades of expansion; one authority takes his stand at a limit of six-fold expansion, another will advocate seven or eight, while a third will draw the line at four-fold; each can cite examples in support of his views, but many disturbing causes attend investigations of the thing whose extents of influence are, with our present knowledge, immeasurable and leave the question unsettled save in its broader aspect. One engineer again declares that all necessary expansion can be secured in one cylinder, while his opponents aver the subsequent expansion of the steam in a second cylinder to be essential to economy.

As a matter of fact, the real theoretical point first to determine is the best grade of expansion, and on this point, making due allowance for practical questions which must be considered in all these cases, a cut-off of the supply of steam to the cylinder at about one-sixth, or at most, one-seventh of the stroke is pretty generally admitted to give the best results; it is true on the one hand that more work still remains in the steam then sent off to the condenser; but then when the grade of sevenfold expansion is exceeded, we find that the disparity between the temperature of the steam as it enters the cylinder and that which it has when it leaves for the condenser, is so great, that the cylinder gets cooled down, and has to get a supply of steam from the boiler to warm it up again before steam is available to propel the piston. Then to remedy this, steam jackets surrounding the outside of the cylinder with steam from the boiler are advocated; but as a fact, although the fact is disputed by a few, the waste in the cylinder is transferred to the jacket, so no saving of fuel is effected and much needless complication of parts is introduced. Now as to the use of one, or of two cylinders; in small engines and of long stroke one cylinder is beyond doubt preferable and sufficient, but with large engines and of short stroke such as our large ironclads have, the question becomes more doubtful; the use of expansion without using also pressures of at least 50 lbs. on the square inch is little avail, and here we come face to face with the real problem, the sudden admission of a steam pressure of 50 lbs. on each square inch of a piston, say 100 inches in diameter, and that piston too, acting on a crank almost on its dead centre, is a critical matter; machinery and fittings must needs be of the best to restrain not merely such a shock, but a rapid succession of them alternating in opposite directions. To avoid this the compound engine is advocated, the compounding of engines is nearly contemporary with steam-engines properly so called; in these engines steam at the high pressure is let to act on a small piston, and then is cut off at say half the stroke, expanded down in the remainder of the small cylinder, and at half the boiler pressure is allowed to act on the large piston; in fact, the compound-engine is nothing more or less than a complicated and vexatious way of diminishing inequality of strains on the machinery. We may now proceed to a little analysis of the different points we have tried broadly to explain to non-professionals, and we have alone to consider now their bearing in relation to war ships of the "Inflexible" class or her successors. The first point then to examine is the facilities we are likely to have in future war ships to expand steam in a simple or non-compound engine. The power of a cylinder measured by its capacity, increases as the square of its diameter, but directly in proportion to its length and length of stroke, but then the longer the stroke the greater the facilities for expansion, and the probably greater breadth of beam of the ship of the future, will enable us to secure a greater length of stroke in proportion to diameter. Consequently in this respect something will be gained for the non-compound engine, as a given power can be had with a comparatively small piston, while the length of stroke will supply facilities for expansion not existing in large cylinders of short stroke. Again, another advantage may be reckoned on. We shall have the benefit to some extent, of the increased piston speed of the longer stroke thus,—at the moment that the steam is admitted on the one piston, and just when it begins to move, the other piston is in full action, and it will, as it were, pull the first piston away from the injurious impact of the entering steam referred to above, and greatly diminish the evil of steam concussion. Here then is one argument in favour of the simple as contrasted with the compound engine, and at the risk of startling the views at present held by, we may say, the entire profession, we remark that it may yet come to pass that we shall find it to our account to arrange the cylinders fore and aft in our war ships, and connect their crank shaft to that of the screw by some mechanical arrangement yet to be devised; as a fact this arrangement, while taking up a little extra room, would give such long strokes and high piston speeds as would enable

us to use much higher pressures than we dare now use, unless in triply compounded engines. Once let a good piston speed be secured in proportion to the number of revolutions, and compounding will become beyond controversy unnecessary.

All the remarks we have made refer more particularly to war ship engines of large size; we will proceed now to contrast the real merits of compound and non-compound engines, and our readers may judge for themselves how far we succeed in proving our proposition, that all the expansion that yields economy of fuel can be secured in a single cylinder.

We will take first the simple or non-compound engine; we will take a cylinder 100 inches in diameter, and 4 ft. stroke, the steam being cut off at one-fifth of the stroke, and the speed of the piston to be 400 ft. per minute, the steam pressure being 60 lbs. per square inch. One leading source of waste of heat is radiation, therefore *cæteris paribus* the engine which exposes the least surface of metal to the steam must be the most economical, so we will compare three different types of engine of nearly the same power, and contrast the respective cylinder and cylinder cover surface to which the steam is exposed, and the temperatures they are lowered to at the ends of the strokes; the calculations are only approximate, as it would be beyond the scope of a magazine article to enter into the deeper subtleties of the heat and expansion of steam, which pertain more properly to the study of the professor.

The first engine we will take to be one with a single cylinder, of which the annexed table gives the particulars.

TABLE I.

Simple Engine with one Cylinder.

Diameter of cylinder .	100 inches.
Length of stroke . .	48 „
Initial pressure of steam	60 lbs. per square inch. Temperature then 308°.
Steam cut off . .	⅕ of stroke.
Mean pressure . .	31·308
Terminal pressure .	12·0. Temperature then 245°.
Speed of piston in feet per minute . . .	400
I. H. P. . . .	2980
Area of metal surface for each cylinder full of steam . . .	22,826 square inches.

TABLE II.

Simple Engine with two Cylinders.

Diameter of cylinder .	75 inches.
Length of stroke . .	48 „
Initial pressure of steam	60. Temperature then 308°.
Steam cut off . . .	⅕ of stroke.
Mean pressure . .	31·308
Terminal pressure .	12·0. Temperature then 245°.
Speed of piston in feet per minute . . .	400
I. H. P. . . .	2980
Area of metal surface exposed to steam .	31,394

TABLE III.

Compound Engine.

SMALL CYLINDER.

Diameter of cylinder	55½
Length of stroke .	48
Initial pressure of steam	60. Temperature then 308°.
Steam cut off . .	0·5 of stroke
Mean pressure . .	50·79
Terminal do. . .	30. Temperature then 275°.
Area of metal surface exposed to steam .	10,771.

LARGE CYLINDER.

Diameter of cylinder.	90·9
Length of stroke .	48
Initial pressure of steam	30. Temperature then 275°.
Mean pressure . .	22
Terminal pressure .	10. Temperature then 240°.
Area of metal exposed	20,169
Total I. H. P. . .	2,584

An examination of the three tables shows that a simple engine with one cylinder exposes 22,826 square inches of metal or radiating surface to each cylinder full of steam, at a lowest temperature of steam of 245° for an indicated horse power of 2,980, or about 7·6 inches per horse power. The simple double cylinder engine exposes 31,394 square inches for an indicated horse power of 2,980 or about 10.5 inches per horse power of a lowest temperature of 245°.

The compound engine exposes a total surface of 30,940 square inches of metal for each large and small cylinder full of steam jointly, and if we take the mean of the terminal temperatures in the two cylinders we have an average lowest temperature of exposed metal of 257°, the exposed surface per horse power, is nearly 12 in. per horse power, and it must be specially noted, too, that we have taken no count of piston or piston rod surface in any of the tables nor of the passages in the compound engines, but the evil influence they exercise in the compound engine is well known. Now we select a comparative table on the performance of the compound marine, as contrasted with the simple engine. We quote it from an able article on the subject published in "Naval Science" for last month.

The three engines are respectively an engine of the simple type working at Saltaire fitted with Corliss valve gear; the compound engines on board the Royal Mail steamer "Elbe;" and compound engines on board H.M.S. "Briton."

	"Saltaire" Engine.	"Elbe" Engine.	"Briton" Engine.
I.H.P. Maximum	560	3,183	2148
„ Mean during this trial . .	480·4	1,452·28	660
Piston speed in ft. per min. . .	420	380	375·4
Volume swept by piston per I.H.P. per minute . .	12·61 cubic ft.	22·5 cubic ft.	41·5 cubic ft.
Boiler pressure .	40 lbs.	45 lbs.	taken at 45 lbs.
Limits of temperature, Fahr. . .	287 and 100	292·7 and 100	292·7 and 100
(*a*) Least possible weight of steam required per H. P. per hour . .	9·33	9·11	9·11
(*b*) Weight of steam used as shown on cards . . .	12·34	14·4	18·96
$\frac{a}{b}$	·756	·632	·480
Description of boiler.	Galloway tube.	Marine.	Tubular.
Sort of coal used.	Ordinary Yorkshire		Nixon's Navigation.
Coal used per I. H. P. per hour as stated	2·33	2·17	1·3
Ditto calculated for evaporation of 10 lbs. water per lb. of fuel . . .	1·7	—	—

Now, a non-professional reader of the above table might perhaps compare the relative quantities of coal burnt in these trials per I.H.P., but such a course would be erroneous, the coal burnt refers alone to the quantity of water evaporated, so that, directly, the engines have nothing whatever to do with the fire; boiler and engine are emphatically separate machines. The duty of the boiler engineer is to evaporate as much water as possible, by the consumption of a pound of coal; the engine-maker's business is to get the greatest work he can out of the steam supplied to him. Now, as it is the engine question we are dealing with here, we may simply ask our readers to compare the quantity of steam used in each of the three engines in the table for an I. H. P. The theoretical minimum measure of steam is nearly alike for each, yet the "Briton" actually uses half as much steam again as the Saltaire engine.

We may now proceed to examine other points in relation to engines for war ships. One of the points most pressing on attention is, on the one hand, the necessity of using high pressure steam, in order to save fuel; and, on the other, the increased danger attendant on the use of such enhanced pressure in action. In one sense, it is probable that just as much destruction of life would attend the sort of explosion that would result from the piercing of an ordinary marine boiler, working with a pressure of 20 lbs., as would result from a boiler explosion at 80 lbs. or 100 lbs. The sphere of action on board a ship is so contracted that every part of her hull is considerably within killing range, to say nothing of the nearly certain subsequent and speedy foundering of the wreck with all hands; certainly the quadrupling of working pressures enhances the destructive effects of explosion, but low pressure explosions would be nearly totally destructive; so that when we consider the boilers for the ironclad of the future, the destructive effects of possible explosions must be dealt with apart from mere relative pressures. We deprecate

the introduction of the pressure factor into calculation in the way some engineers and shipbuilders seem to use it. The attendant mischief of such a proceeding is already apparent, because we find the question of what is the best engine, complicated needlessly by this question of having one pressure of steam for cruising and another lower one for fighting. Superficially examined, it is a very enticing project to have an economical high pressure when there are no shots flying, and another lower pressure when there are—the objections to the scheme are, however, great. We have shown above how dubious, to say the least, is the advantage of the compound engine to economize fuel; and we now say, in addition, that engines for war ships ought to be the simplest of the simple, and compound engines certainly are not so. In addition to this, the advocates for what we will for convenience designate as differential pressures would have to further complicate the compound engine by separate arrangements for taking steam direct into the large cylinder from the boiler; and the introduction of such would expose the machinery to a new danger. Man is but fallible; and it might very well happen that some time or other, perhaps at a very critical time, the direct steam supply would be left open to the large cylinder, when it ought to be closed, with the nearly certain result that on steam being turned on, the end would be blown off the large cylinder, if indeed worse did not happen. As regards the engines best suited for the ironclads of the future, the leading features must be the greatest simplicity, the least possible number of parts, the longest reasonable stroke of piston, the use of lined cylinders, so that no metal shall have steam at one side and atmospheric influence at the other; the simplest form of slide that will give the best and quickest supply and cut off. As to the boilers, since the successful introduction of the surface condenser, now pretty well tested, there is no reasonable doubt that the days of the old plate-iron tanks, called by courtesy "marine boilers," are numbered, the sectional boiler is the marine boiler of the future; even now it is in successful operation, and that is a great step with a branch of marine engineering as yet but in its infancy. More difficulty necessarily attends the designing of a sectional boiler for a war ship than for a merchant steamer. The war boiler, if we may use the term, should be designed on the principle of confining damage done to the immediate tubes actually injured; this, with our present experience, can alone be done by making the communication between tube and tube as contracted as possible. We believe, however, that the sectional boiler of the future will have valves or other provision for, in the truest sense of the word, confining the results of the injury of any tube or set of tubes to them alone, the pressure in and efficiency of the rest of the boiler remaining intact. It is not enough for us to rest content that a shot in the boiler of an ironclad shall not result in the blowing of the ship to ribbons, but we must *seek to retain the motive power as long as possible.* In conclusion, we would say with Dr. Ernst Alban, years ago himself the apostle of high pressure,—"Let us prove all things, and hold fast that which is good."

UNITED STATES LIGHT-HOUSE SUPPLY STEAMER "DAHLIA."

WE extract from the "New York Nautical Gazette" the following description of a screw steamer, just completed, and intended for the light-house service on the lakes. The hull is of iron, the plating being carried up to the main rail. The length over all is 141 ft. 6 in.; beam 25 ft.; depth, from top of floors to top of deck beams, 10 ft. 6 in. The frames are placed 21 in. apart, from centre to centre. There are three iron keelsons riveted to the floors, in addition to bilge keelsons and hold-stringers of angle iron, all of which run as far fore and aft as was found practicable. She has a solid bar keel of the best hammered iron, and the stern and rudder posts are also of the same material. The deck beams are of T bulb iron, and are secured to the frames by plate iron gusset pieces. Stringer plates are riveted on the tops of the beams, and extend entirely around the vessel.

Additional stringer plates have been placed fore and aft on each side of the centre line of the deck. There are five iron water-tight bulk heads. The hull has been constructed in a most thorough manner, and the "Dahlia" will undoubtedly prove to be a vessel of extra strength for her class. The officers' cabin and state-rooms are located on the after part of the main deck, and extend from side to side; under them are store rooms and the after-hold. Forward of these there is an officers' bath room and water closet, and an engineer's store-room on one side, and on the other the cabin pantry, linen-room, and lamp-room. All the doors are hung on parliamentary hinges. The engine-room is located amidships, and under the main deck forward of this room is the boiler and forehold. The coal bunkers have a capacity of eighty tons. The galley is on the main deck forward of the smoke stack, and has convenient communication with the cabin. The forecastle, for the crew, is on the forward part of the main deck, and is arranged for comfort and ventilation. Beneath this are the sail and store-rooms.

On the forward part of the main deck is one of Perley's patent capstans, worked from the spar deck. The spar deck extends entirely over the vessel, and above the main rail the hull is extended up to this deck by joiner work, completely enclosing the vessel.

All the room between the cabin aft, and outside of the engine-room and galley, and the forecastle, is open deck or cargo space, and is completely protected from the weather.

The mate's room, chart room, and pilot house, are on the upper deck. The latter apartment is a model room, having plenty of space, and that most important consideration, an unobstructed view to every point. The vessel will be worked from this deck, and here are located her boats, which have been built with a view to arduous service.

The motive power is supplied by a condensing engine, the cylinder being 34 in. in diameter, and 30 in. stroke, driving a propeller 9 ft. in diameter. There is one return flue boiler 8 ft. 8 in. in diameter, and 23 ft. in length, with steam chimney.

The "Dahlia" is rigged as a fore-and-aft schooner. All of the standing rigging is of the best quality of wire rope. The arrangement for stowing and handling the anchors is remarkably convenient. There are two ordinary bilge pumps, and two additional pumps, to be used as fore and bilge pumps, to be worked by the crew; there is also an extra steam pump which can be used for the above purposes, and also to feed the boiler. There is a bilge pump attached to the main engine, making six pumps in all. In addition to these, there is the bilge injection and Barnum's bilge attachment to the air-pump, the whole series giving extraordinary facilities for freeing the ship of water.

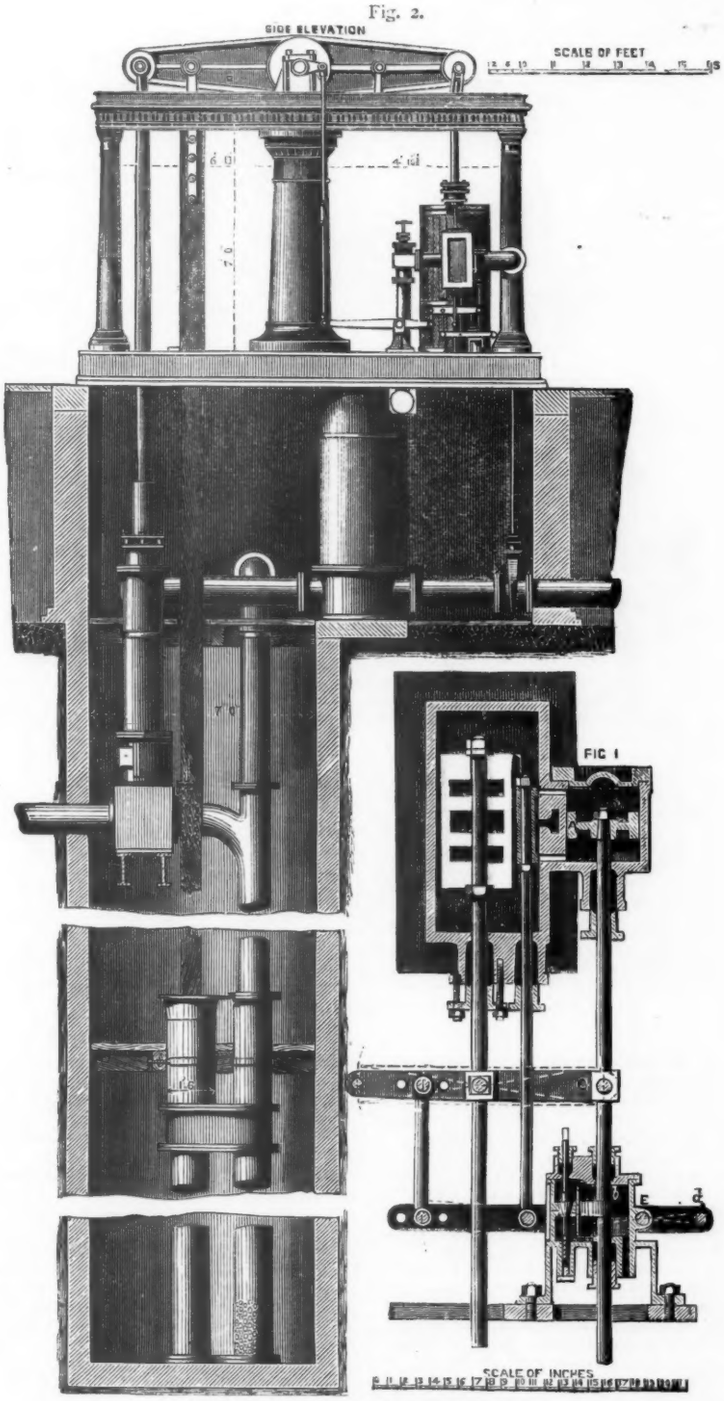
The "Dahlia" is designed for service on the upper lakes, where the light-house board is extending the system of lights, beacons, and fog signals as rapidly as the limited appropriations at their disposal will admit. She is a handsome and substantial steamer, reflecting credit on her designer and builders, and will be welcomed by navigators on the lakes, where increasing commerce urgently demands additional warnings of danger, and channel guides.

She obeys her helm readily, and there is almost an entire absence of vibration. On a pressure of 35 lbs. of steam, 84 revolutions of the screw were obtained, giving a speed of 12 knots in slack water.

DIFFERENTIAL PUMPING ENGINES.

WE illustrate examples of some pumping engines constructed on a patent secured by Mr. Henry Davey. No class of steam machinery exercises a larger influence on the greatest industries of the United Kingdom than pumping engines. The necessity for draining our mines, the immense quantities of water to be removed hourly night and day all the year round, and the great heights to which the water has, in numerous instances, to be raised, unite to render this branch of mechanical engineering of the greatest importance. Probably many of our readers will feel surprised to learn that there are examples in mining operations where the weight of water is four times as great as is the weight of coal raised from the same mine; thus, every pound of coal brought to bank entails the necessity of lifting four useless pounds along with it, and this, coupled with the present dearness of coal, continues to stimulate hydraulic mechanical engineers to fresh exertions, to secure economy of fuel in pumping engines. In a paper read on the 6th of October last, before the Society of Engineers, Mr. Davey remarked that improvements effected in the Cornish pumping engine during twenty years had effected a saving of £90,000 per annum, or, at the price of coal prevailing when the paper was read, £140,000 per annum. The advance in mechanical knowledge teaches us now that the Cornish engine in its very best form is antiquated, better duty can be obtained from machinery less cumbrous and bulky, less expensive either to make or maintain. The enhanced price of coal has given a spur to improvement in steam machinery, and has brought high pressures forward to a prominent position. The much debated practice of compounding engines has become more general, and

Fig. 2.

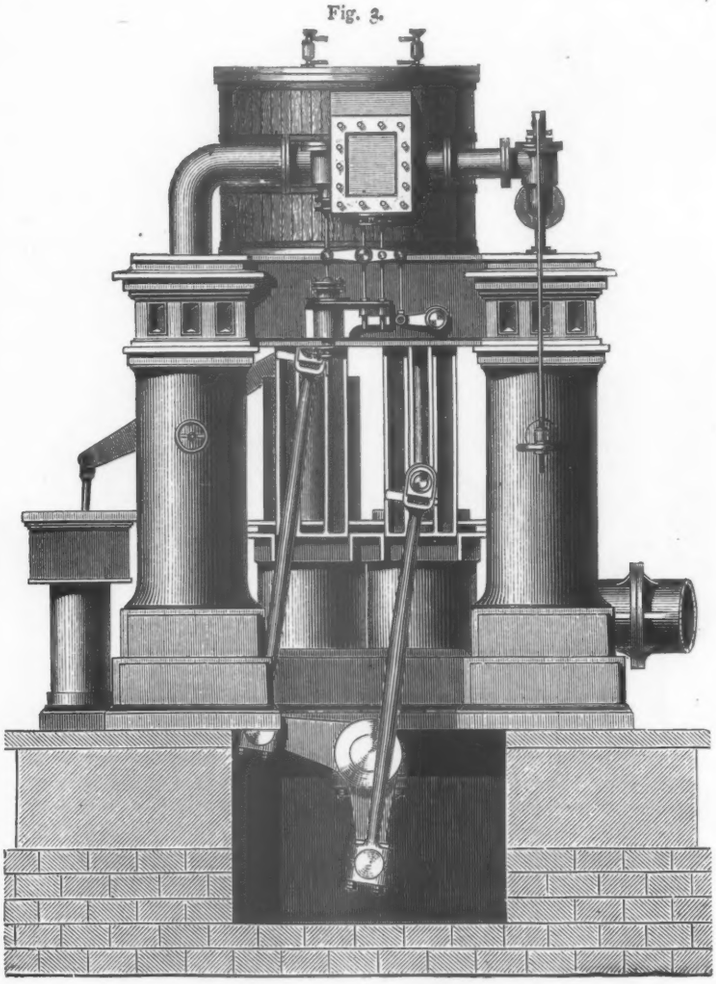


DIFFERENTIAL BEAM PUMPING ENGINE.

the point about it now most debated is the best method of applying the principle.

The illustrations, figs. 1, 2, show some sectional details of Mr. Davey's valve gear. In devising this gear the inventor kept before him the necessity which exists, that pumps to be most effectual must not work too rapidly, because otherwise the valves not having time to settle to their seats, leakage occurs, and moreover the valves and seatings are beaten to pieces. He also recognized the necessity that exists for securing a perfect equality between the load and the power where great pressures of steam, such as now obtain in steam engineering, are dealt with; with these objects in view he invented the following gear. On the piston-rod of the engine is placed a pivot-joint fitting, which engages in a lever or bar crossing the piston-rod at right angles

Fig. 2.

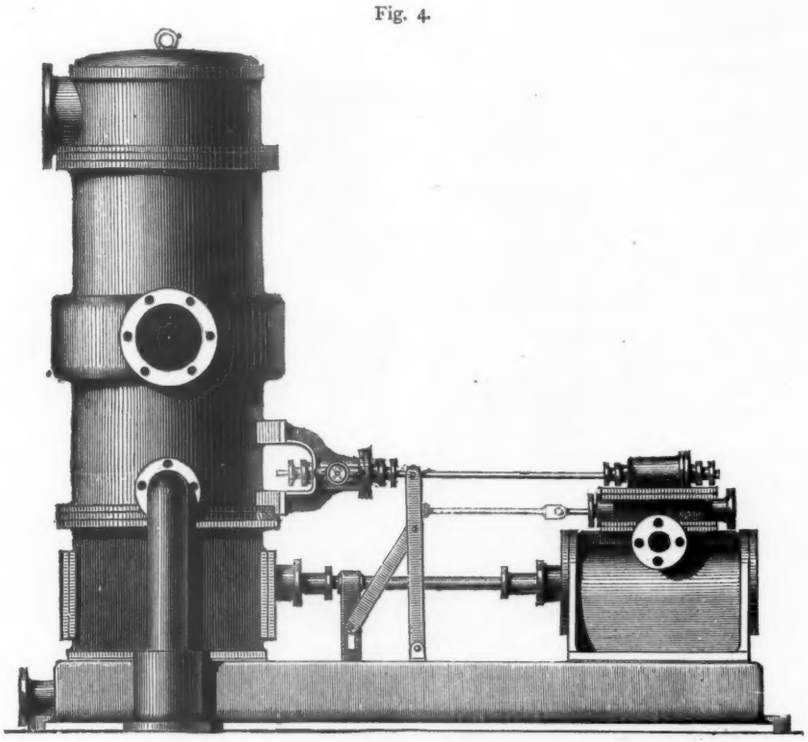


COMPOUND DIFFERENTIAL PUMPING ENGINE.

and held at one end by the pivot-joint on the piston-rod; it will be obvious that as the piston-rod reciprocates it will cause the end of the cross bar to move with it. This bar is connected to the slide-valve of a subsidiary cylinder, and moves it. The bar is prolonged beyond its connection with the subsidiary valve-spindle and its farther extremity engages in a rod prolonged at either side, the one end being attached to a piston in the subsidiary cylinder situated over the main slide valve box, and on the back of the main slide-valve are two projections, which are alternately engaged by a projection on the back of the main slide governing a steam supply to the subsidiary piston. The other end of the subsidiary piston-rod is connected to a little piston working in a cylinder supplied with water; this water passes to either end of the cylinder through a small cock which can be opened or closed at pleasure, either wholly or in part. Evidently the piston in this cylinder, called the cataract cylinder, cannot travel faster than the water passes through the tap, as the piston pushes it out of the one end of the cylinder with the other end. We must explain also that the supply ports of the main cylinder are just reverse in position, as contrasted with those of an ordinary engine; thus, in a common cylinder set vertically, the upper supply port in the face on which the slide-valve works, supplies the upper end of the cylinder and the lower port the bottom end. In the cylinder under notice,—it is supposed, for convenience of explanation, to be set vertically,—the upper supply port communicates with the lower end of the cylinder and *vice versâ*, hence it is evident that if the main piston be at the upper end of the cylinder, the slide valve must be moved upwards to admit steam over it instead of downwards, as in the ordinary arrangement of steam cylinders.

The action of the entire mechanism is as follows. We will suppose the main piston progressing upwards in a vertical cylinder; as it moves, it actuates the cross bar in such a way as to let steam below the subsidiary piston, by moving the slide governing its steam supply. The subsidiary piston, but for the cataract cylinder, would fly up suddenly; as it is, however, it moves the outer end of the cross bar with it more rapidly than the other end is being moved by the main piston-rod; and the difference in speed of the former end of the cross bar in excess of the latter end throws the subsidiary valve forwards more quickly than the main piston moves, and carries the supply slit or port in the subsidiary valve beyond the main supply port, and this subsidiary valve still moving, strikes the one projection on the main slide and moves it upwards, letting steam in above the main piston, this main piston having completed its up stroke returns again and brings its end of the cross bar with it; this cross bar shifts the subsidiary slide, and at a certain point in the stroke admits steam on the subsidiary piston, which instantly moves to the other end in the same direction as the main piston, shutting off its own steam-supply and causing the projection on the back of its own slide-valve to again shift the main slide down, letting steam below the main piston, and thus the action goes on in regular alternation. To start the engine, steam is admitted on the subsidiary piston, which at once sets the steam valve of the main cylinder. The action of the subsidiary piston is of course controlled by the cataract piston at

Fig. 4.



DIFFERENTIAL CIRCULATING PUMP AND SURFACE CONDENSER.

the other end of the rod, and this cataract is so arranged that the main piston has a certain period of rest at either end of its cylinder, so as to give the pump-valves that time of rest described above as a necessity for pumps intended to give the maximum duty. The section, fig. 1, shows the valve gear, which is called differential from the difference in the speeds of the slide valves and in the cut-off due to the differences of action of the cross bar, which, as we have shown, is moved now by the main piston at one end and now by the subsidiary piston at the other. In the section, fig 1, *b* shows the cataract piston, *d* is one end of a second lever or cross bar introduced to suit certain requirements in the engine illustrated in the main part of the cut. Mr. Davey says himself of the engine illustrated by figs. 1, 2: "The main slide valve spindle is attached to the centre of a lever, one end of which derives its motion from the engine and reciprocates in equal times with it, while the other end is actuated by means of a subsidiary piston, and is made to constantly reciprocate in equal times by means of a double acting cataract governor. The movement of the cataract end of the lever is constant and has necessarily a lead in advance of that of the opposite end at the commencement of each stroke. With a constant load on the engine the lead will be constant; but the slightest variation in the load causes a corresponding instant variation in the lead, and, as a consequence, the cut-off takes place earlier or later as the load is decreased or increased."

When a pair of engines are to be worked together the respective movements of the two are made to retain a due relation to each other by joining the subsidiary piston-rods to a cranked shaft, the cranks being set at a right angle, a small fly wheel on the cranked axle securing smoothness of action. Fig. 3 shows a compound engine designed for pumping water for the supply of towns, and capable of raising 90,000 gallons per hour, 150 ft. high. The machinery measures 12 ft. × 8 ft. × 13 ft. high; the rocking shaft and cranks below are introduced to connect the high pressure and low pressure pistons together in such a way as to equalize the actions of both, and render the effective action on the pump plungers equal throughout the stroke, and to guard against the varying strains called into play by the momentum of the heavy masses of water put into rapid motion and which forces do not of themselves vary in a degree corresponding to the variations of force due to the alterations of pressures of 80 or 90 lbs. steam expanded six or eight fold in the cylinders.

For mining and general purposes Messrs. Hathorn, Davis, Cambell and Davey make horizontal pumping engines, either with single cylinders or else with a high and low pressure cylinder. For these last they use very considerable pressures, ranging from 70 to 120 lbs. per square inch and expanding eight or ten times. We understand that this firm has lately erected one of these compound engines of 100 horse-power, working with 120lbs. initial pressure, and it works with less than 2¼ lbs. of coal per horse-power per hour. The same firm are also adapting this new differential valve gear to existing Cornish pumping engines, the mechanism being well adapted to work the double beat valves of these engines by a suitable modification of the parts. Pumping engines constructed to embody all the arrangements we have just described are also fitted to work at the bottoms of mines and to force the water to the surface of the ground, and a pair of them at the Clay Cross Colliery pump against a load of 1,000 ft. of water. Another pair at Newton Cap pump against 240 ft. load. The dip in which the Clay Cross engine works once became flooded and the engine worked under water for two months, during which time it was never even seen. Fig. 2 shows a differential pumping engine arranged as a beam engine.

These differential engines have been lately rendered more economical of fuel, by the addition of condensers, placed either at the end of horizontal engines, having the air pump worked by a tail-rod from the main piston, or else by a separate hydraulic engine worked by the pressure of the water in the main, or else the condenser is set vertically near the steam cylinder. Fig. 4 illustrates a separate surface condenser and its circulating pump worked by differential gear, intended for addition to existing non-condensing engines, so as to make condensing engines of them.

DISTANCE-MEASURERS FOR MILITARY USE.[1]

By Major P. Henrard, Belgian Artillery.

OF all the conditions essential to accuracy of fire with guns of every description, the most important is an exact knowledge of the range. Without it, however good the weapon, however skilfully aimed, the practice must of necessity be bad. Certain practical rules have been laid down to guide us in estimating distances by the eye alone; but differences in the ground, in the state of the atmosphere, in the intensity of the light, etc., so completely change the aspects of the objects observed upon, that, even at distances of less than a kilometre, the most practised observers are liable to make errors of estimation amounting to 100 kilometres and more.

In artillery practice, with projectiles carrying percussion-fuzes, the small cloud of smoke arising from the explosion of the bursting-charge will generally enable us to decide whether the shot has struck in front of or behind the mark, and so by degrees to correct the aim. But when the range is considerable, the errors will often be very great, and the process of correction very slow. Accordingly, the necessity of devising an instrument to show the range with a fair amount of accuracy appears to have suggested itself in some shape or another to artillerists everywhere. Nor have solutions of the problem been wanting; but the appliances proposed have not all equally satisfied the conditions which render instruments of the kind serviceable on the field of battle. We shall attempt a brief explanation of the principles adopted in a few of these instruments in different countries.

Hanoteau's Field Sextant-Lunette.

This instrument, the invention of Major Hanoteau of the Belgian Artillery, is based on the following principle:—

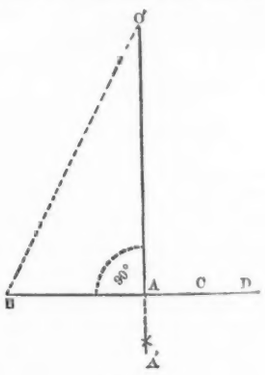


Fig. 1.

In the right-angled triangle A O B (fig. 1), the angle at O, or its complement O B A, being known, if the base A B has a constant length, say 100 metres, we can easily prepare a table showing the values of O A corresponding to the different values of the angle at O.

The difficulty is to measure very small angles corresponding to very long distances. Let us now see how this has been solved by Major Hanoteau. In his first instrument, brought out in 1867, under the name of the *Sextant-multiplicateur*, the angle was measured by a common, pocket sextant-like arrangement of mirrors; but to get a closer approximation, the movement of the index-mirror was communicated, by an arm terminating in the arc of a circle, to the cylindrical axis of a movable sight-bar, by which the measured angle, increased in the proportion of 6 : 80, was cut off on a graduated limb provided for the purpose.

In the present form of the instrument, the sextant-lunette, the arrangement is different. There are two mirrors, as in a pocket-sextant, and so arranged as to show a right angle when the index is set to zero. The play of the index-mirror embraces fifty half divisions (corresponding to 50 degrees of the sextant), *i. e.* 25 on either side of the perpendicular. It is regulated by a screw, forming a tangent to the plate on which the mirrors are mounted; one complete revolution of the screw carries the index-mirror through five half-divisions, or 5 degrees of the sextant. The circumference of the screw-head is divided into fifty equal parts; and an indicator is added to show the number of revolutions described. A double vernier enables us to read the divisions on the limb to minutes. The instrument is completed by the addition of a small Galilean telescope in lieu of sights.

The observer, with the sextant-lunette set to a right angle, takes up his position at A′, and places between himself and the object whose distance is sought, but 15 to 20 metres to his right, a flag or other like mark at C. He then moves in the direction of O until a point A is reached, where the images of C and O coincide in the mirrors. Here he remains until another mark is set up at D, 20 or 30 metres beyond C, and so aligned that D coincides in the instrument with C and O. The points C and D give the direction of the base line A B perpendicular to A O. A B is then measured = 100 metres; and the observer moves to B, and again brings the images of the marks at C and D to coincide with that of the object O. The angle shown by the instrument will be the complement of the angle O A B. A *table of distances*, engraved on a thin sheet of copper wound round the case of the instrument, gives the distance corresponding to the angle indicated.

We may dispense with the assistance of flags or other marks by having two observers, each provided with a sextant-lunette; one to remain stationary at B, and the other to move backwards and forwards along the line A′A, with his instrument set to a right-angle, until the images of the observer B and the object O cover each other.

Gautier's Telemeter.

The pocket-telemeter of Captain Gautier, of the French Artillery, which gained for its inventor the silver medal at the Paris Exposition of 1867, appears at first sight not to differ materially from Hanoteau's sextant-lunette. As in the latter, two sextant-mirrors, set at an angle of 45°, serve to mark the base line, and the distance is computed from this base and the sine of the subtended angle, $A O = \frac{A B}{\sin. O}$ (fig. 1). Finding that the value of A O is not sensibly altered when the angle O A B, in place of being a right-angle, is 8° less, Captain Gautier has availed himself of the latitude thus given to lay down his base more rapidly with the aid of a single flag. To this end the movement of the index-mirror of the sextant is so restricted that the angle between the two mirrors cannot vary more than 8° from a right-angle. The object being given, the observer selects some natural mark or object—a tree, a church-tower, the gable of a house, or the like—as nearly as the eye can judge at right-angles to the line whose length is sought. Shifting his position a little as required, he at the same time moves the index-mirror, until the images of the two objects are brought in conjunction. At this point he sets up a mark and then moves along, aligning himself on the mark and the natural object to any convenient distance, so as to lay down a base line. At the end of the base the images are again brought together, not with the aid of the index-mirror, but by a refracting-prism mounted on a cylindrical support, one half revolution of which corresponds to a displacement of 3° in the image. The graduations marked on the cylinder show the values of $\frac{1}{\sin O}$ for the distance through which it revolves. They are marked in decreasing order from infinity to 20, commencing at the initial point of the prism, and indicate the number of times the base is contained in the distance sought. At any single variation of the observed angle, the distance rotated by the axis of the prism corresponds to an angle eighty times larger than that described by the index-mirror, thus affording greatly increased facilities of reading-off.

The instrument possesses incontestable advantages in the length of the base-line being arbitrary, and its direction, within certain limits, alterable at will. It may not be always possible to work from a base of given length and bearing. It may happen that after the line has been laid down the object cannot be seen from the further extremity; this will, of course, entail a repetition of the operation, involving loss of time, always objectionable in the field, which might be avoided were the length arbitrarily assumed. The deviation of 8° from a right-angle also affords facilities for laying down a base in cases where the ground may not be adapted to the trace of a right-angle.

A length of base-line approximating to $\frac{1}{100}$th of the distance sought will generally give sufficiently close results with this instrument. If the conditions are less favourable, a longer base, equal to $\frac{1}{50}$th or $\frac{1}{20}$th of the estimated distance, may be used. Experiments made in Switzerland show that the probable error in a single observation was 1·47 per cent. of the distance; the mean error in ten measurements was 1·08 per cent.

It is desirable that each instrument should be carefully tested

[1] *Annuaire d'Art, de Sciences et de Technologie Militaires.* Première année (1873).

and adjusted before the graduation of the prism, so as to correct those errors of construction which are inherent to all instruments depending on an arrangement of mirrors or refractory prisms.

NOLAN'S RANGE-FINDER.

This distance-measurer, the *range-finder* of the English, has been adopted in the Russian as well as the English Artillery. It comprises a couple of instruments, each carried in the wheel-box of one of the flank pieces of the battery, seventy yards of measuring tape on a reel, and a *computing cylinder*. Each instrument consists of a couple of telescopes, crossed, one long, carrying at one extremity a vernier graduated to $\frac{1}{3}$ minute; the other a short one, fixed at right-angles to it and provided with an index-arm and graduated limb. In ascertaining the range, the flank guns of the battery are first laid for the object, with which they form a pretty close approximation to an isosceles triangle. The long telescopes are laid in rests fitted on the guns for the purpose, and are adjusted to the object by correcting the aim.[1] The two observers then measure the angles adjacent to the base with the aid of the shorter telescopes, whilst two assistants rapidly ascertain the distance between the guns with the tape.

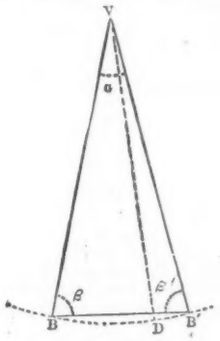


Fig. 2.

In the triangle V B B′, whose base is very small in comparison with the two sides, the assumption, that the distance sought is equal to the diameter of the circle passing through the three points of the triangle, will involve an error of less than $\frac{6}{10000}$ths of the said diameter, an error which may therefore be neglected at long distances.

If V D be this diameter, we shall have, approximately:—

$$V B = V D = \frac{B B'}{\sin \alpha} = \frac{B B'}{\sin (\beta + \beta')}$$

whence, log. V D = log. B B′ — log. sin $(\beta + \beta')$.

This formula may be calculated with great rapidity with the aid of the *Computing-cylinder*. This is a wooden instrument, consisting of three movable cylindrical rings, traversed by an axis, on which is fixed an intermediate ring. The instrument is used in the same way as a *slide-rule*, and may readily be learned by a few days' practice.

The time required, including the laying of the guns, is 40 to 80 seconds. The probable error does not exceed $\frac{1}{50}$th of the distance sought.

This distance-measurer has the following serious defects:—1st. Besides the measuring-tape, *three* distinct instruments are needed, which are very apt to be separated when the guns of a battery are acting independently. 2nd. Seven persons are required for its expeditious use. It has also a defect, common to all instruments employing two observers at once at some distance apart. Mistakes, or want of preconcerted arrangement, both very common in practice, may lead them to observe upon different objects, or widely different points of the same object, and thus entail very considerable errors, as we shall have to show, in speaking of Bylandt's Stadiometer.

STUBENDORF'S, PASCHEWITCH'S AND GOULIER'S TELEMETERS.

The task of designing a telemeter for field-service having been confided to the Topographical Bureau of the Etat-major, by the Russian Scientific Commission, on the 31st October, 1869, the following solution of the problem was proposed by Staff-Colonel Stubendorf:—If, at the two extremities of a base-line B C of constant length, we set off two right-angles, so that one side of each may pass through the object V, whose distance is sought, the side B D of the angle V D B will cut off from the prolongation of the line V C a length C D proportionate to the sine of the angle C B D = B V C; and, C D being known, $V C = \frac{(B C)^2}{C D}$.

The apparatus consists of two pentagonal prisms, to set out

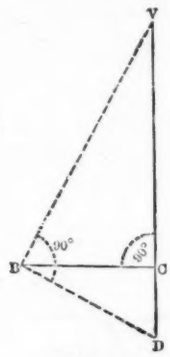


Fig. 3.

the right-angles; a measuring-tape 10 *sagenes* (23·3 yards) long; and a ruler 30 inches in length, graduated according to the formula $n = \frac{b^2}{s}$, in which b is the length B C, and s the distance required, and carrying a sight-vane.

Two observers, each with a prism, station themselves 10 *sagenes* apart, at the extremities of the measuring-tape, the ends of which are attached to the feet of the prisms. One observes on the point V and the observer B; the other on the same point and the sight-vane D, which is moved, with the left hand, by the observer C, along the ruler C D, the latter being fixed upon his prism in the line V C. The division on the ruler, at which the vane is stopped on a preconcerted signal from the observer at B, gives the required distance at once.

The limit within which the distance of an object can be ascertained with this instrument, under the most favourable atmospheric conditions, is about 1,300 metres.

In November, 1871, M. E. Paschewitch[1] proposed a telemeter based upon the same principle as Stubendorf's.

At the two extremities of a base-line of 25 metres, he sets up two tripods B and C, one of which carries a graduated bar with sight-vanes. A telescope with cross-wires and a mirror fixed at an angle of 45° with the axis, is laid in turn on each tripod, and allows the point D to be determined and the distance read off on the bar.

The use of the telescope with cross-wires, and the comparative rigidity of the apparatus at the stations B and C, give to Paschewitch's telemeter an accuracy which is not possessed by Stubendorf's. But, on the other hand, it has less portability, and is much less suited for field use.

M. Goulier, Chef de Bataillon of the French Corps du Génie,[2] has invented a telemeter differing from the preceding in so far that it can be used without the pentagonal prism. The instrument, which is set up at B, has two lenses—one plano-concave and fixed, the other plano-convex and movable—mounted on a slide running in a graduated groove and worked by a projecting stud. This arrangement of lenses takes the place of a prism. By moving the slide, the observer at B displaces the movable lens, so as to bring the line B C into the direction B D, and to enable him to see both the V and the observer at C.

The deviations being proportionate to the displacements of the convex lens, and the base being a constant, the distance may be read off directly on the graduated sides of the groove.

Experiments made in Switzerland show that the maximum probable error in a single observation with this instrument is about 1·49 per cent. of the distance; the mean error in ten consecutive observations was not more than 1·02 per cent. of the distance.

GASTALDI'S TELEMETER.

If at the point C, on the line D C B perpendicular to A B, whose length is sought, a mirror F C G be placed at an angle of 45°, and from D a perpendicular be dropped to meet the line of the

[1] In the English field equipment, small lateral adjustments are given with a horizontal screw without shifting the trail.

[1] "Dingler's Journal," Nov. 1871. "Giornale d'Artiglieria," 1872, p. 53.

[2] "Zeitschrift für die Schweitzerische Artillerie," July, 1869.

ray E C reflected from the point A, the triangles A B C and D C E will be similar, and we shall have,

$$A B = \frac{C B \times D C}{D E.}$$

Gastaldi's telemeter consists of the following apparatus :—1.

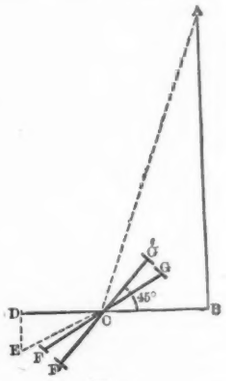


Fig. 4.

A prism to give a right angle; for setting out the base B D; 2. A telescope D C, 20 centimetres (7·4 in.) long, carrying a mirror F C G inclined to its line of axis at an angle of 45°.

If we wish to place the telescope so that the object A may be seen by reflection in the mirror making an angle of 45° with the base-line D C B, we must shift it from D C to E C: but if we desire, without disturbing the telescope D C, to fix the point B directly and the point A by reflection, through the eye-piece D, we must alter the position of the mirror from F C G to F′ C G′, that is to say, we must move it through the angle G C G′ = ½ D C E.

If this movement of the mirrors be effected by an ½ millimetre micrometer screw D E, with its head divided into 100 equal parts, working against the extremity of an index arm 20 centimetres long, the displacement will obviously be equal to ½ D E, and the value of D E will be ascertained within an hundred millimetres nearly.

With a base C D of constant length = 20 metres, D C will be 0·20 metres, and a table may be prepared showing the values of A B corresponding to the several values of D E.

If the objects to be observed upon had always well defined contours, reflecting micrometers would give very good results; but this is not the case in practice, and besides errors inherent to the instruments themselves, we have to take account of personal errors on the part of individual observers. Thus it happens that two observers using different instruments, or even the same instrument, will often obtain very different results.

As regards Gastaldi's instrument it should be said that it is easily manipulated; but it requires a tripod-stand, which renders it comparatively of little practical utility on field-service.

Plebani's Autostadiometer.

Having set out, with a prism or cross telescopes, a base-line C D, at right angles to the line S C whose length is sought, let us place at D a quadrant A D B, with its sides parallel, respectively, to the lines S C and C D, and carrying a graduated sliding sight-bar, working in the direction of the radius.

Now, if we suppose that the portion G D of the bar G M contains as many graduations as there are metres in the base C D, we may conceive a curve D L O, which shall cut off upon the same bar G M as many graduations G L as there are metres in the hypotenuse S D of the right-angled triangle S C D.

The equation of this curve is determined by the formula :

$$S D = \frac{C D}{\cos a}$$

$$\log. S D - \log. C D = \log. \frac{1}{\cos a} \quad . \quad . \quad . \quad (a)$$

If the sliding bar is so graduated that the distance of any point upon it from the commencement of the scale represents the log. of the number marked thereat, by sliding back the bar from D to G, we get

$$G D = \log. C D,$$

and if G L = log. S D, the point L will be in the curve sought.

The equation (a) shows that this will be a curve described from the point D, with a radius vector, D L, varying as the difference of the logs of the hypotenuse, S D, and the base, C D, and also as the log. of the proportion $\frac{S D}{C D} = \frac{1}{\cos a}$.

The sliding bar is therefore merely a logarithmic scale, in the

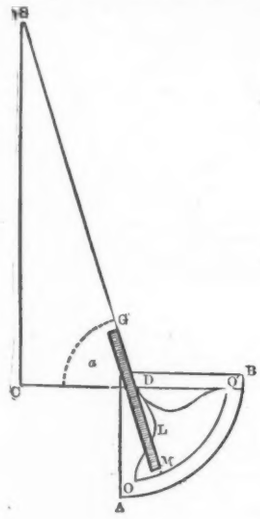


Fig. 5.

graduations of which it is, however, convenient to multiply the logarithmic numbers by a co-efficient less than unity, so as to keep the size of the instrument within suitable limits. We may therefore take, as a radius vector, $r = k \log. \frac{1}{\cos a}$. This instrument has been tried in Italy, and found to give very good results. Without departing from the original principle, the inventor has made various improvements in it, rendering it more suitable for field-service. It has, however, the defect of requiring a tripod stand.

Bylandt's Stadiometer.

Bylandt's stadiometer (fig. 6) consists of a rectangular brass plate, 25 centimetres (9 in.) long by 7 centimetres (2¾ in.) broad, carrying, near the middle of one of its shorter sides, a movable pivot, on which works a graduated bar, D A, furnished with an eye-piece at one extremity. The movement of the bar about its pivot is limited by the stops, MM′ and LL′. When shut back against MM′, the bar is parallel to the short sides of the rectangle. The stop, L L′, is fitted with a hinge, and when folded down alongside of MM′ it exceeds the length of the latter by 3 millimetres ($\frac{1}{10}$ in.) and reduces the angle described by the bar proportionately. A line L′S, engraved on the face of the plate, and forming a prolongation of the inner face of the stop, LL′, cuts off on the bar, as it turns on its pivot, the number of divisions of the latter corresponding to the distance sought. The pivot is mounted on a slide working in a groove 3 centimetres (1 in.) in length, and its movements are regulated by the screw, G. The instrument is fitted with an iron rest, so that it can be hung upon a gun or waggon-wheel.

Two observers and an assistant are required to use this stadiometer. The instrument having been attached to the wheel in a horizontal position, and V being the object whose distance has to be ascertained, one of the observers places himself at any suitable point, B. He is provided with a pentagonal prism, to mark a right-angle, the sides of which pass through the object V and the pivot D. The prism is mounted on a reel, upon which is wound a measuring-tape of a given length.

As soon as the first observer has taken up at his position at B, the assistant stretches the tape to its full extent, BC. The second observer, stationed at the wheel, adjusts the instrument, and turns the plate upon its pivot, so that the sight-bar, when shut back against the stop MM′, may lie in the direction B D; he then folds back the stop, L L′, bringing the bar against its extremity L, and then, with the aid of the screw G, adjusts the pivot D, so that the point C may appear in the line of prolongation of the bars. Again moving the latter, he directs it upon the object V. The number marked on the bar at the point W, where it is intersected by the line L′S on the face of the instru-

ment, shows the distance sought. It will be seen that the two triangles C B D and D L M give

$$B C : M L = B D : D M,$$

the two similar triangles V D B and D M W give, in turn,

$$V D : D W = B D : D M,$$

then $\frac{V D}{D W} = \frac{B C}{M L}$; and if B C is constant = 15 metres,

we shall have $V D = \frac{15 \text{ metres}}{0{\cdot}003} \times D W.$

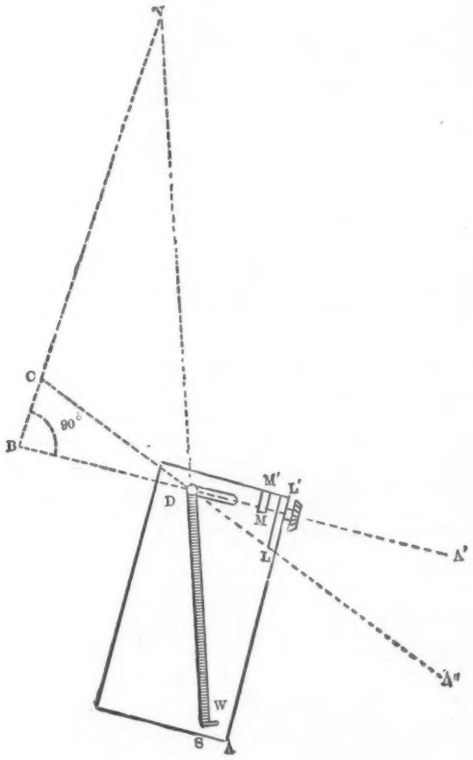


Fig. 6

As the length of the base line is not a factor of the required answer, it may be taken arbitrarily. Still, for long distances, it is desirable that the base should be as long as possible.

If the object observed upon have considerable width and

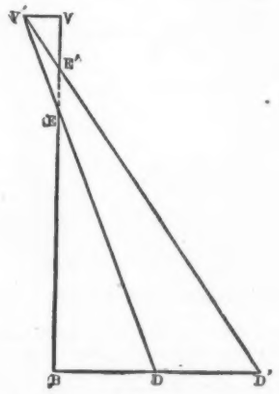


Fig. 7.

depth, it may happen that the two observers select each a different point of the object. Allowing these points to be only 5 metres apart, an error of 20 to 200 metres may be produced in the estimate of the distance.

The like triangles give (fig. 7)

$$V V' : B D = V E : B E, \text{ and } V V' : B D' = V E' : E' B, \text{ or}$$

5 metres : 20 metres = V E : 2000 — V E,

or 5 metres : 200 metres = V E' : 2000 — V E',

and V E = 400 metres; V E' = 487 metres.

According as the base-line is 20 metres or 200 metres in length, the error will be as if one observer had chosen a point, E, and the other a point E'; and V E and V E' will express the amount of error in each case. Consequently, it is of much importance that exactly the same point should be observed upon by both.

This stadiometer, which is very easily manipulated, was submitted by the inventor, Count Bylandt d'Arnhem, to a committee of Netherlands officers, in September, 1872, and was found to give remarkably satisfactory results. It has also been very favourably reported upon at the Belgian School of Gunnery, at Brasschaet, notwithstanding certain defects of construction, which may readily be rectified.

BOOKBINDING IN THE INTERNATIONAL EXHIBITION.[1]

By H. T. Wood.

AMONG the various classes represented in this year's Exhibition there is none which seems to attract the visitors more than that devoted to bookbinding. It so happens that most of the other classes are of a very special character, and tend to interest rather those intimately connected with the subject treated than the general visitor. With bookbinding the case is different, and if in too many instances only a cursory glance is given to the cases in which lie, side by side for comparison, the laborious handiwork of past centuries and the brilliant productions of modern machinery, there can be no doubt as to the interest shown by those who collect round the counters where the work of bookbinding itself is carried on.

Though an exhaustive history of the binder's art has yet to be published, still so much has been at divers times and in divers places written about it, that there can be no necessity here for giving any account of the ordinary methods employed. Nor can space be spared for any sketch, however brief, of the gradual rise and progress of the art. The subject is a tempting one, but as it cannot be treated at proper length, it is better not to touch upon it at all, but to devote this article to an account, incomplete indeed, but still as correct as may be, of the present condition of the art, endeavouring at the same time to indicate the progress that has been made during the two periods, 1851 to 1862, 1862 to 1874, since the first Great Exhibition.

In the Jury Reports on the Exhibition of 1851, several pages are devoted to bookbinding,[2] and there are also some remarks on the designs shown, in the "Supplementary Report on Design," by Mr. Richard Redgrave, R. A., which concludes the volume.[3] The account there given may serve to show with some exactness the state the art was then in, and the amount of progress that has since been made.

"Modern bookbinding is carried on in England on a scale of such magnitude as the binders of former times could scarcely have foreseen. The production of books greatly exceeds that of any former period, and has caused the application of so much machinery to bookbinding, that it may fairly be said to have become a manufacturing business. Books, handsomely bound, gilt, lettered, embossed, and otherwise ornamented, no longer depend upon individual skill, but are produced with extraordinary rapidity by the aid of machinery. Mr. Burn, of Hatton Garden, first introduced rolling machines to supersede hammering; the iron printing presses of Hopkinson and others were altered to form arming-presses by which block-gilding, blind-tooling, and embossing can be effected with accuracy and rapidity. Leather covers embossed in elaborate and beautiful patterns by means of powerful fly-presses, were introduced by M. Thouvenin in Paris, about twenty-five years ago, and almost simultaneously in this country by Messrs. Remnant and Co., and by Mr. De la Rue, who were quickly followed by others. Embossed calico was also introduced about the same period by Mr. De la Rue; hydraulic presses, instead of the old wooden screw-presses; Wilson's cutting machines, which supersede the old plough; the cutting tables with shears, invented by Mr. Warren De la Rue,

[1] From the "Journal of the Society of Arts."
[2] "Jury Reports," p. 423. [3] Ibid. p. 740.

and now applied to squaring and cutting mill-boards for book covers; all these means and contrivances, indispensable to large establishments, prove that machinery is one of the elements necessary to enable a binder on a large scale to carry on that business successfully."

In the report on bookbinding in the Exhibition of 1862, the jurors state that they had given up as impracticable the attempt to form any detailed comparison between the exhibits of 1851 and 1862, because no one of the jurors had served for both exhibitions. The specimens shown in 1862 they divided into three classes. First, bindings of an elaborate character, jewelled, enriched with chasings of the precious metals, or with carvings of ivory, and enamelled. Second, elegant and solid bindings, showing high-class workmanship. Third, bindings of an ephemeral character, designed for popular works.

In all these classes they noted an improvement. In the first, extravagance had, they considered, to some extent given way to utility. In the second, there was more originality of design and greater care in the combination of colours. In the third, there was increased cheapness of production and a greater amount of artistic taste. A marked feature of the third class was also the very much greater rapidity with which the work could be accomplished.

In the present exhibition there is perhaps no division in which more decided progress has been made during the past ten years than in bookbinding. True, in the highest class of work there is little improvement, nor perhaps can much ever be made, but in the cheaper sort of bindings there has been a very marked change of recent years, both as regards the workmanship of the bindings, and still more as regards the methods by which they are produced.

For convenience sake it may be as well to accept the classification of the 1862 report, with some slight modifications, and to arrange the bindings as (1) fancy or very elaborate bindings, in which unusual or costly materials are used for the covers; (2) leather work; (3) cloth and paper bindings. To these may be added a class (4), bindings for ledgers, &c., of a purely useful character.[1]

Bindings of the first class are really separate works of art, and depend for their value on the skill of the artist who designs and the artist who executes the ornamentation; not upon that of the bookbinder proper. They are *sui generis*, and, however beautiful or costly, can perhaps hardly be said to have much influence upon an art now practised on so large a scale as that of bookbinding. In the second class it can only be said that the extension of a truer artistic knowledge and more correct taste, which has been among the most valuable results of our exhibitions, has shown itself in bookbinding as in ornamentation of every sort. As the popular taste has become purer, it has also grown more exacting, and has produced a demand—which has been fully met—for more harmonious combinations of colour, more artistic and purer designs. Though a tendency to overload a costly binding with ornament is still occasionally visible, it is so to a less extent than formerly, and our most recent productions generally show a beauty of design that rivals the work of any preceding age, joined with an excellence of workmanship such as it may be doubted has ever before existed. Still it cannot be said that any considerable advance in this class has been made during the last decade beyond the regular and steady progress common to all arts of design during that period. As regards the method of production, that remains quite unchanged from what it has been for years. The work is all done by hand, at least all the highest class is so done; the hammer for backing and the hand-plough for cutting are still used as of old, and the process in all its details remains the same.

It is in the third class, among the comparatively inexpensive bindings of cloth, that the chief improvements are to be noted. The immense multiplication of books has necessitated a correspondingly increasing cheapness in bindings. When books were few and libraries small, their possessors were able to expend considerable sums on the covering of a single volume, but to clothe an average modern library in leather is now a matter of no small cost; and the result has been that the principal energies of the trade have of late been directed towards the production of a handsome and durable substitute for morocco and calf. On the continent and in America readers are still content with simple paper wrappers, but these are scarcely at all used in England for anything less ephemeral than a magazine. Even the paper-covered boards in which cheap novels are published have to a great extent been superseded by covers of cloth, often of a very neat and attractive character, and always a great improvement, both as regards appearance and durability, on the paper.

That this change has been effected as rapidly as it has is due to the introduction of machinery to accomplish nearly all the various processes required in bookbinding. This fact is noted in the paragraph above quoted from the reports on the 1851 exhibition, and the machinery therein alluded to has been most extensively developed both in power and in the variety of its application since that time. The presses mentioned have been improved and further developed, while several new machines have been introduced. Among the principal of these are "rounding" and "backing" machines, saw benches worked by steam power, and some improved trimming machines. All these have certainly come into use since the first Great Exhibition, for though machines for backing and finishing backs were shown in 1851 by Mr. Starr, of New York, so little attention was paid to them that the jury were not able to see and report upon them.

To give an idea of the extent to which machinery is now applied, it may be worth while to give a brief sketch of the various processes which a book undergoes in being bound in cloth. The ordinary process of hand-binding has been so often described that there can be no necessity to refer further to it here; but as it does not appear that any description has ever been published of the process of machine binding, no apology is needed for repeating much that is familarly known to all specially concerned in this important business.

The sheets, which have been "gathered" at the printer's, are delivered to a girl, who folds each by hand. Machines have been invented for this work, and indeed are largely used for newspapers, but as yet they have not come into extensive use in binding books. The difficulty is that the machines fold by the edge of the paper, whereas for book work the sheets have to be folded by the type. There are indeed machines which overcome this difficulty by means of register points like those used in printing presses, but these require that similar points should be set in the printing press, and except in houses were both printing and binding are done there is a difficulty about this. Still machines are used by many houses abroad, and some at home. In the "Graphic" office there is a machine which not only folds that journal, but "insets" the inside sheet within the outer one.

After being gathered and "collated" in the usual manner, the sheets are pressed between rollers, or in a hydraulic or screw press.

The next thing is to saw the notches in the backs of the sheets in which the bands lie. This is still generally done by hand in the usual way, but in large establishments, and where a great number of the same book have to be bound up, machinery is used. A figure (Fig. 1) of the saw bench is given. Under the table is

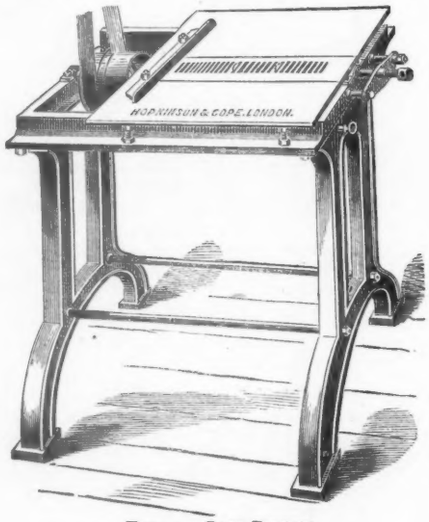


FIG. 1.—SAW BENCH.

a spindle on which are fixed several circular saws, the edges of which protrude through slots in the table. The number and position of the saws are regulated according to the number of cuts required. After this the sheets pass to the hands of the sewer; and here there is no improvement in the old sewing press with the cords stretched across, to which a girl secures each sheet separately by a peculiar stitch. After being sewn, the sheets, now forming a book, are again placed in the hydraulic with boards between the books.

So far the work is now done mainly by hand, as it has been

[1] Shown in the Stationery Class (C. xxviii.) in 1862.

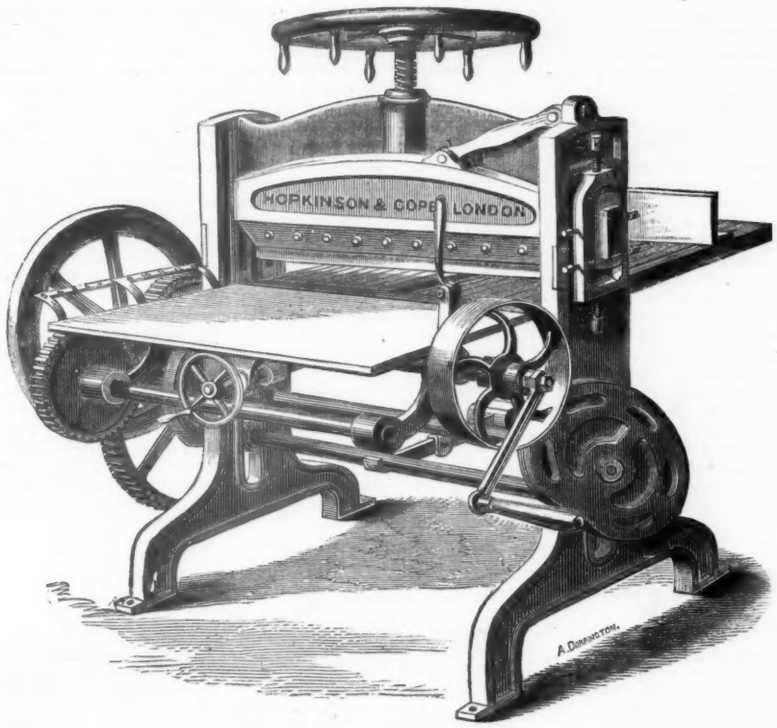


FIG. 2.—CUTTING PRESS.

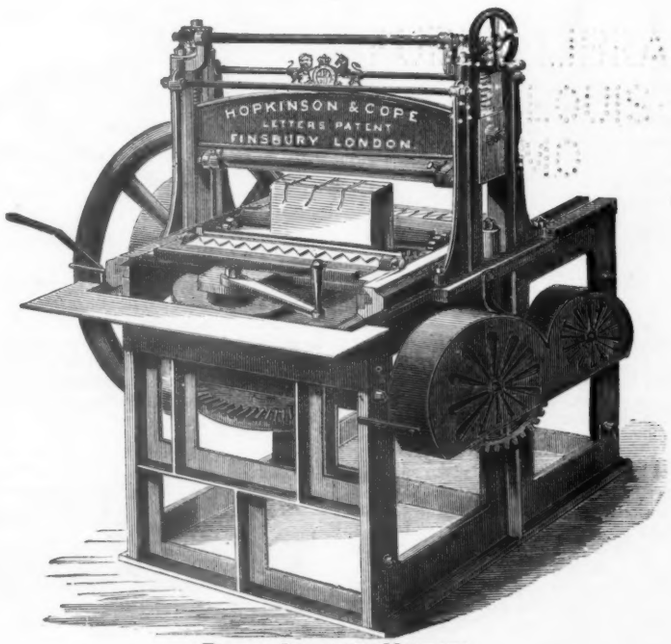


FIG. 3.—ROUNDING MACHINE.

done for years. The next processes are those in which machinery comes principally into action. The first thing is to cut square the edges of the leaves. This of course was originally done by a hand-plough working over the edges of the book while it was screwed down in a vice, technically called a "laying press;" it is now done by one of several machines. These machines are of two classes, according as they are intended merely to trim off the rough edges, leaving as wide a margin as possible for the benefit of the future binder when the book is to be bound up in leather, or to cut the edges once for all as they are intended to remain. The former are known as "trimming machines," the latter as "cutting presses" or "guillotines." The latter have been in use for a considerably longer period than the former, and are now, of course, more extensively employed. To dispose of the trimming machines first. In the earliest of these a circular rotating cutter revolves by the side of a table having a to-and-fro

motion. On this table the book is clamped so that its fore-edge is brought against the revolving cutter, and as the book is carried along, a cutting of the required breadth is taken therefrom. The bottom edge is then treated in the same way, the head being generally left uncut. This circular trimming machine is principally used for magazines and similar work. For book work a straight trimming machine is generally used. In this a rising and falling table is situated below a horizontal knife, to which a to-and-fro motion is given from a cam on a shaft at the side, at right angles to the knife. The book is placed on the table, where it is held down by a presser-foot, against adjustable guides, and by the action of the table it is carried upwards against the knife edge, which, with a rapid saw-like motion, trims off the rough edges of the sheets. Of course, very little pressure is required, and the sheets are not squeezed together as in the machine next to be described.

The cutting press (Fig. 2) is in the main only a greatly improved form of the old hand-screw guillotine, which was the first improvement on the hand-plough. In it the book is placed against a guide on a fixed table, and held in position by a presser-foot. A knife then descends between vertical guides with a slightly drawing motion combined with its vertical motion, and shears away the required amount from the sheets.

The next process is that of gilding. This is effected in the same way as formerly, except that a number of books are all treated at once. They are clamped down in a sort of vice, called a gilding press, the glaire brushed on, and the leaf applied and burnished in the usual way by hand. In the most recent description of press the frame in which the books are held is mounted in trunnions, so that it can be turned over, and both edges of the book be got at without removing it. After this they pass to the "rounding" machine (Fig. 3), where the round back and corresponding hollow fore-edge are given to them. This process was till lately only to be accomplished by the hammer, though there have been several machines invented for the purpose. In 1868, Messrs. Cope and Bradbrooke brought out a machine, which is now in extensive use. In this the book is clamped with its back upwards between two horizontal cheeks on a traversing table which reciprocates backwards and forwards under a fixed roller, adjustable as to height, so that, as the book is carried under it, the roller is forcibly driven from side to side of the book, forcing the back over and causing it to assume the usual convex form.

Next the book passes to the "backing" machine (Fig. 4). This is a small hand-machine, instead of being, like all the above, worked by power. Its object is to form the recess or groove along the sides of the back in which the boards lie. Its operation is tolerably simple. The book is held in a vice, in which it is clamped by a lever worked by a treadle, the book being supported with its back just over the jaws of the vice, so that the backs of the outside sheets may be forced over to the proper shape. The roller shown is then brought down on the back, and passed backwards and forwards across it two or three times. The combined pressure of the roller and the jaws of the vice cause the book to assume the required form. This machine is the one exhibited,

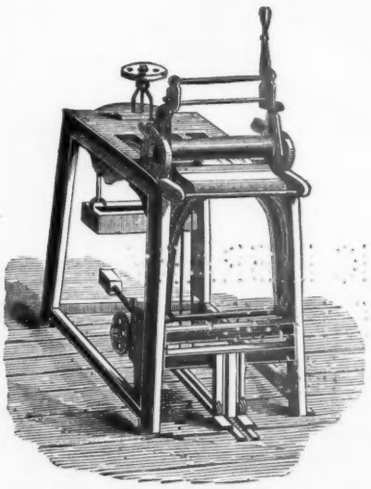


FIG. 4.—BACKING MACHINE.

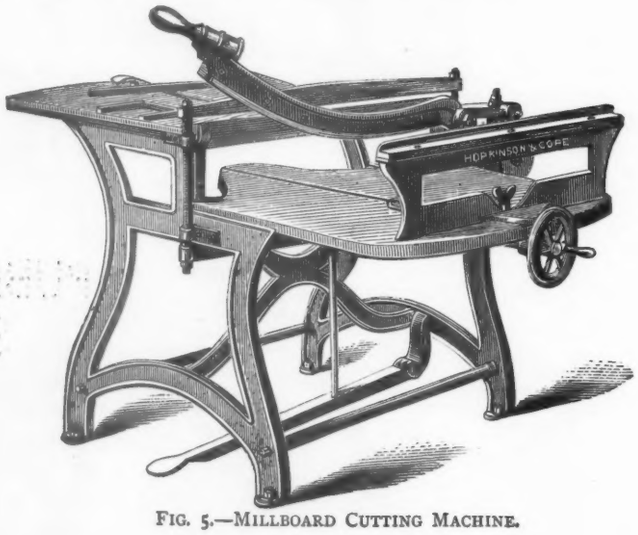


FIG. 5.—MILLBOARD CUTTING MACHINE.

in its original form, at the 1851 Exhibition by Mr. Starr, of New York.

The sheets have now been brought to the proper shape, and only require to have a strip of canvas pasted over the back, for them to be ready for insertion into their covers. The preparation of these is another department, and must be described separately.

The first process is that of cutting the millboards into suitable shapes and sizes. This is effected by the apparatus shown as fig. 5, in which a large knife with a curved blade works on a pivot at one end, against the edge of a table. The millboard is held by a bar pressed down on it by a treadle, and its edge comes against an adjustable guide, seen on the right of the figure, which is set according to the width of the cover required. If the edges are to be bevelled, this is done in another machine (Fig. 6). The board is laid on the table with a straight-edge over it, while a second straight-edge rises slightly above the edge of the table, and forms a projecting rim for the edge of the board to bear against. The straight-edges are set as required, to allow more or less of the corner to be cut away; and a knife passed along them, as shown, strips off the corner of the board, leaving a neat and bevelled edge. A recent improvement has been to fit to the machine a gouge, which slides in a carrier along guides by the side of the straight-edge, in place of the knife. By this a round bevel can be cut. The cloth covers are cut to the required size, and they are then glued, the boards laid on them with a strip of paper for the back, the corners of the cloth cut away, and the edges turned evenly in. The case, so far complete, is hung up to dry, and is then ready to receive whatever ornamentation may be considered proper.

Of this ornamentation the greater part is of three sorts, blind

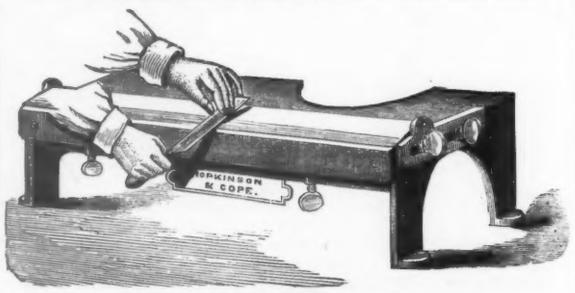


FIG. 6.—BEVELLING MACHINE.

and black printing, and gilding. The machines used for all these processes are of the same character in the main. The blind printing and the printing in gold are done in the same press, the only difference being that when the work is gilt, leaf is applied to the parts required, in the usual manner, with glaire. The

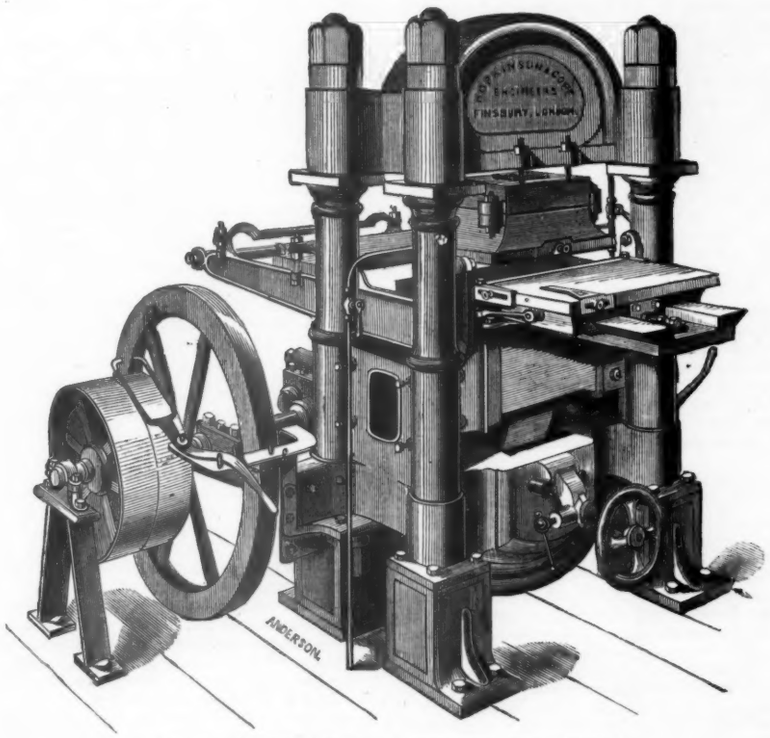


FIG. 7.—ARMING PRESS. (HOPKINSON AND COPE'S.)

case, with or without the gold-leaf on it, is placed on the bed of the press, and a die is forced down on it from above, this die being heated by a gas jet or steam-pipe in a hollow box above it. For printing in black or other colour, another apparatus is used. This resembles in its main principles an ordinary printing-press, except that the printing surface is reversed, and acts downwards. The plate, on which lies the case to be printed, travels backwards and forwards automatically under the die, and has at one end an inking roller. The case is placed on this reciprocating bed, and it travels back under the die, the roller inking the die as it passes under it. The die is then forced down on it, the bed being held stationary below it. The die then rises, the bed moves forward again, and the case is removed to be replaced by another. This press is also equally applicable for blind work, the inking apparatus being detached, and the die being heated as before. By means of a recent improvement by Messrs. Hopkinson and Cope the same press can be used first for blocking, and immediately afterwards for printing, the heater-box being cooled by a jet of water. Two of these arming presses are shown, figs 7 and 8.

Of course any or all these processes can be applied to each case, and the perfection to which the machinery has been brought enables this to be done with the greatest accuracy of register.

Another process commonly employed, and capable of producing very pleasing effects, is that of "inlaying." In this a small piece of paper, of a different colour to the cloth, is pasted on the case, and the gilding and stamping effected over that. By this means the effect is frequently produced of lettering or devices in colour on a gilt ground, the cloth of the cover being of a different colour. Judiciously employed, this device has very pretty results, but sometimes—and this is often seen in German cloth binding—the patch-work appearance given by a mixture of several different colours is by no means pleasant or attractive. Perhaps the richest and best effects are produced by a mixture of black and gold printing. The ease with which the process is now carried out has made this style of work a very favourite one, and it is becoming the most usual way of getting up books which it is desired to render attractive at a moderate cost.

The book itself, and the case which is to hold it, having been thus separately prepared, it only remains to fasten the two together. This is rapidly done by hand, the canvas strips already

FIG. 8.—ARMING PRESS. (GOUGH'S.)

glued on the back of the book being, with the fly-leaves, then pasted down on to the cases. It is not usual to add head-bands to books in cloth, though in some highly-finished examples this further finish is given to the book.

Such, in the barest possible outline, is the usual method employed in binding books on a large scale at the present day. So complete and rapid in their action are all the machines employed, that the bookbinder is able now to keep pace with the printer, and when once all the preliminary preparations have been gone through, the blocks made and mounted, the "making ready" finished, the process goes rapidly and steadily on, and the books are turned out at a pace little short of marvellous.

Nor is mere rapidity of production the only, or the principal, gain. When a large number of books have to be bound it is almost as easy and cheap to produce an elaborate and handsome case as a plain and simple one. At all events, the slight additional cost of each volume is far more than repaid by the very great additional attractions it possesses.

The entire process as above described is shown by Messrs. Simpson and Renshaw, in Room I., among the machinery in motion, as is also the process of binding in leather. A variety of examples of modern library book-binding in russia, calf, and morocco, bound in the Exhibition, is shown in their cases.

M. Zaehnsdorf also shows in Room XII. the process of binding by hand in leather, the whole work being in the latter case done by hand, in the old way.

In class 4, as above divided, viz. ledgers and account books, the chief advance made of late years has been in the direction of improved appearance. No longer satisfied with the old-fashioned rough calf, which soon gets soiled, our binders adapt to these purposes russia and morocco, and turn out volumes of a far more attractive character than of old.

Besides the introduction of machinery, and the improvement in taste, it is not easy to note any very great alteration of late years in the ancient art of bookbinding. The processes of binding in leather are now just what they have always been since the infancy of the art. The materials in use now for all sorts of bindings have undergone little change or improvement of late. They are, of course, as they always have been, most various; but it cannot be said there have been of late many introductions of importance. The use of ivory for bookbinding is well known, and a recent improvement in the method of cutting it, by which a continuous sheet is stripped from the circumference of the tusk, the whole tooth being thus formed into a single sheet, enables this material to be much more extensively and economically used than formerly. The process of india-rubber binding, patented many years ago by Mr. Hancock, is still used to a considerable extent. In it, as is well known, the sheets are all separate, and are united by a layer of india-rubber applied to their edges. The great advantage attaching to this method of binding is that the books can be opened out perfectly flat. For MS. books it is useful, but for account books a great drawback to it exists in the ease with which a leaf can be extracted and replaced.

A very fair idea of the existing state of the bookbinder's art may be obtained from a general view of the exhibits. There are examples of ancient bindings in sufficient number to illustrate the principal schools of bookbinding, while side by side with them are placed their modern imitations, as well as the more original work of our own age. To tell the truth, the style which is distinctly the product of our time compares but ill with the solid work of our fathers, and of those who still carry on similar work. However useful and valuable in their own way may be the bright cloth and gold bindings of a modern bookseller's shop, they seem tawdry and poor by the side of the massive tomes over which the ancient workman lavished weeks and months of patient toil, or even the no less laboured productions which are now sent out by our chief binders. Steam and iron can reproduce by the thousand objects of sufficient artistic merit and real beauty, but the unyielding force of the arming-press can never give us the free flowing lines that run from the tool of the skilful artist, nor can the rapid action of the other machines employed ever turn out the solid workmanship of the careful handicraftsman. Still there must always be abundance of room for the two sorts of work. The connoisseur of books will never be able to dispense with the one. The ever growing public of book-readers will provide an ample market for the other. Great as is the demand for cheap and quickly-made book covers, there is no falling off in the requirements for the highest class of bindings. Lovers of good books are as anxious as ever to lavish on their treasures all the adornment that the resources of the binder can supply, and it is satisfactory to note that these resources are as ample and as ready as of old.

MINING APPLIANCES.[1]

THE work before us is the result of instructions issued in 1868 by the Secretary of the Treasury of the United States to the commissioners of mining statistics, which instructions indicated, as one of the most important subjects for inquiry, "The relative merits of the various inventions, machines, and mechanical contrivances in use or projected for the reduction of the precious metals, and for all other purposes connected with the business of metallurgy;" and in consequence thereof, Mr. Blake undertook the preparation of a report upon the subject, which was submitted to Congress in 1870, and of which, although the author in his diffidence is pleased to offer an apology for its shortcomings, we have no hesitation in saying that we have as yet met with nothing more complete in detail, or comprehensive in the general scheme and arrangement. Indeed, we marvel, looking at the time said to have been employed in its preparation—the winters of 1869 and 1870, how so much information could have been gathered together in so short a period, and more so, perhaps, at the industry which has so well accomplished its arrangement and collation.

We may premise here that Mr. Blake's book, as indeed may be gathered from what we have just said, is no mere glance at mining in general; not simply a statement of what has been done in two or three different districts; but that, although confessedly giving greater attention to what has been achieved in Western America, it embraces descriptions of mining machinery and tools, from the pole pick of the Cornish miner, the packer or poker common at St. Ives and St. Just, the Saxony gad; hand and machine drills of every known character, from the earliest percussion instruments to the annular diamond drill of Messrs. Severance and Holt; whilst the coal-cutting machinery of these latter days is duly illustrated and described—indeed, further than this—for the proposal of Mr. Samuel P. Bidder, jun., to use the force of a hydraulic press as a substitute for powder in fiery collieries, of the arrangement for which he exhibited a model at the Institution of Civil Engineers (England) in 1869, is duly recorded.

We are, however, anticipating our author; and taking, therefore, his work in regular order, we find that he divides it (in addition to an introductory chapter on the manufacture of mining machinery in California, which manufacture, we confess, we had no idea had reached the development here indicated) into five sections—the first entitled "Breaking down rocks and ores;" the second "Boring and excavating by machinery;" the third, "Transportation, ventilation, &c.;" the fourth "Breaking, crushing, and grinding ores;" the fifth "Separation and concentration;" all of which are again subdivided into chapters devoted to the separate details connected either directly or indirectly with the principal questions. Our readers will therefore not be surprised, from the foregoing category, to find that the first chapter in the first section is devoted to "Water—hydraulic mining." Pointing out that as water appears to have been nature's principal instrument in preparing the gold-laden earth deposits, so also is it the surface-miner's great agent for breaking down and re-assorting them; and this is effected by two processes—first, the "hydraulic," the operation of which is to break and disintegrate; and the second, "sluicing," which has to separate, assort, and concentrate.

In hydraulic mining the essentials are a sufficient head or quantity of water, say from 100 ft. to 200 ft. fall, to enable it to be conducted in pipes, and delivered through nozzles, against the base of an earth, which it undermines, the overhanging masses falling to the base and being—for the water will penetrate every crack and pore—thoroughly broken apart and loosened. The Californian district, consisting principally of high mountains, whence flow numerous streams towards and across the gold regions, permits the accumulation of sufficient supplies of water for this method. Indeed, the main difficulty connected with it is to obtain the necessary drainage for getting rid of the water after it has done its work. This is most frequently done by tunnelling through the rim rock, so as to tap the lowest point in the basin; but in many cases this has been found a tedious and an expensive operation—in some instances, indeed, five, and even seven years, have been necessary for driving such tunnels, and that at an expenditure varying from 10 to 60 dollars per lineal foot.

[1] *Notices of Mining Machinery and various Mechanical Appliances in use, chiefly in the Pacific States and Territories, for Mining, Raising, and Working Ores; with Comparative Notices of Foreign Apparatus for similar purposes.* By William P. Blake.

The second operation, that of sluicing, will of course be very readily understood, and has, as we have said, for object, to separate, assort, and concentrate. It is carried on in various manners—in sloping troughs and over shelving tables, and for its purposes the water already used in getting the ore is generally available.

We now come to an extremely interesting, although it be apparently as yet an undecided question. It is, "What is the miner's inch of water?" Mr. Blake says that the usual pressure or head is 6 in., and the aperture of delivery a slit 1 in. and about 24 in. long, which can be closed to any desired degree; and he adds that it is usual to consider the "miner's inch" as the quantity which will pass through an opening 1 in. square under a mean pressure of 6 in., the said quantity being under these conditions, 2,274 cubic feet in twenty-four hours. There seem, however, to be various practices obtaining, both as to the head of water and the shape of orifices, amongst the numerous water companies (for be it understood, that the supply of water to miners is quite a separate speculation to that of mining itself, and employs a large amount of separate capital) of the Californian territory. For instance, the Eureka Lake and Canal Company deliver water through an aperture 2 in. high, and under a pressure of 6 in. considers that such an aperture 20 in. long is equal to 40 in., a calculation the absolute correctness of which we do not quite see. Upon the Excelsior ditch, and also on the Sear's ditch, the water is delivered under a pressure of 10 in., whilst at Smartsville, water is sold by a head of 9 in., with a 4 in. opening 125 in. long. The quantity discharged, the co-efficient of discharge = ·0615, is 106·6 cubic feet per hour, or 1·7767 cubic feet per minute. Of course, as Mr. Blake says, it is not very easy in face of the varied cost of water, and other circumstances, to very accurately compare the relative expense of mining by the different methods. He, however, gives a table extracted from a work by M. Laur (who was sent out by the French Government to investigate the subject), "De la Production des Métaux Précieux en Californie," which shows such an extraordinary difference in the cost of working a cubic metre, = 35·316 cubic feet, of gravel, that we give our readers the figures themselves to judge by :—

	£	s.	d.
By the pan . . . say .	3	2	6
By the rocker . . „ .	0	16	6
By the long-tom . . „ .	0	4	2
By the sluice . . „ .	0	1	6
By the hydraulic washing „ .	0	0	3

And it would further appear that this comparatively infinitesimal last charge includes the water cost, inasmuch as he gives the charges for working 28,080 cubic metres, or approximately 1,000 cubic feet, as follows :—

	£	s.	d.
Water	208	6	8
Manual labour	36	0	0
Sundries	20	16	8

It may be useful here to add that in the inedited report by Professor Silliman upon the Blue Gravel Gold Mining and Water Company's claim, near Smartsville, a cubic yard of the gravel there requires for washing 17·2618 cubic yards of water, or say 3·486 gallons.

In his second chapter our author comments upon "hand tools;" and in our opinion very justly remarks that, though it may "seem trivial to devote much space to the forms and peculiarities of tools used daily by miners," yet when we consider how much more the skilful workman can accomplish with light, strong, and well-proportioned tools as compared with clumsily and roughly made ones, the importance of the subject duly appears.

Perhaps the most important of any of the tools used by the miner or coal-getter, is the pick, and of the types of these Mr. Blake describes, as being especially used on the Pacific slope, three, viz., the "surface pick," or ordinary excavator's pick; the "drifting" or "quartz pick;" and the "poll pick." We need not describe the first, its form being universally known, beyond saying that its weight varies from 4 lbs. to 7 lbs., that it is made either with a round or flat eye to receive the helve, and its medium length from point to point is say 27 inches; the drifting pick does not run quite so heavy and differs from that first named in that the interior curve turns at the ends towards the exterior one, which is doubtless an advantage in hard rock; its medium size is 24 in. with an eye 3 in. by 1 in. The third form of pick is the poll pick, which is in fact a pick and hammer in one, combining as it does a long sharp point for drifting and a hammer-head for striking and breaking the rock or driving gads. This pattern is a great favourite with the miners of Cornwall, and is much used in that county, in Derbyshire, and in the North of England, where vein-mines are worked; its medium is about 4½ lbs. and its length over all, say 16 in. Besides these varieties Mr. Blake gives a table shewing the length of handle, length of head, and weight of mining picks in different countries; these vary very considerably, especially in the weight, the light Cornish poll running only to 2 lbs. 10 ozs., whilst the Monmouthshire rock mandrel reaches 9 lbs. 5 oz. with a length of head, wedge-pointed and chisel-end, of 24 in.; this is a heavy tool, but we have ourselves seen it freely and steadily used by miners in the district named. At the conclusion of this chapter there is a short dissertation on hand-drills, consisting however principally of extracts from a lecture by Mr. Warrington Smyth, for which, see the "Mining Journal," January 1870, with which many of our readers are probably acquainted, and which serves as an introduction, as it were, to Chapter III. on the all important subject of "Explosives."

Mr. Blake naturally enough points out, quoting, however, from the very lecture just mentioned, that for many years, even centuries, gunpowder was the only explosive known, or at all events used, in mining; and individually we can recollect such being the case, the new compounds, however, are almost endless in number; and however popular ordinary powder may still be for blasting purposes, we cannot ignore these new and powerful creations of science.

The first of these "moderns," if we may be allowed the expression, was probably gun-cotton, which, as our readers are doubtlessly aware, has been most extensively employed in many countries, notably, amongst others, at the quarries of the Austrian Government up the Danube, and also in North Wales; it possesses certainly this advantage, that weight for weight it will do five or six times the work of gunpowder. The use of gun-cotton, however, was very shortly, to a great extent at least, superseded by that of nitro-glycerine, which appears to have been discovered by M. Sobrero, in the laboratory of Professor Pelouze in 1847, although its explosive powers were not noticed until brought to light by M. Nobel, a Swedish mining engineer.

It is a liquid obtained by the action of concentrated nitric, or of a mixture of nitric acid of 40° strength and sulphuric acid of 66°, upon glycerine, the re-action being represented by

$$C^6\,H^5\,O^6 + 3\,NO^5\,HO = C^6\,H^5\,O^3\,3\,NO^5 + 6\,HO$$

The appearance is much like that of olive oil, and its taste is sweet and slightly fragrant. To further quote Mr. Blake, we may say that "in the combustion or explosion of nitro-glycerine, seventeen equivalents of oxygen out of the eighteen are absorbed by combining with the carbon and hydrogen, thus leaving one equivalent of oxygen free. Each one hundred parts of the oil when exploded produce by weight

Water . . .	20·0 parts
Carbonic acid . .	58·0 „
Oxygen . . .	3·5 „
Nitrogen . . .	18·5 „
	100·0

and as the specific weight of the blasting oil is 1·6, one volume produces

Steam . . .	554 volumes
Carbonic acid . .	469 „
Oxygen gas . .	39 „
Nitrogen gas . .	236 „
	1,298 „

It is claimed for this explosive that it will exert, weight for weight, eight times the force of gunpowder. It is, however, an extremely dangerous agent; for although when pure, nitro-glycerine is not liable to spontaneous explosion under a heat of about 360° Fahrenheit, yet if impure and acid, it changes into a mixture of oxalic acid and glycerine, and may then explode. This has indeed been exemplified by many terrible accidents, which have led to a modification of it in the mixture now known as dynamite or giant powder, which is formed by mingling nitro-glycerine with infusorial earth, which gives it the appearance of moist sawdust of a grayish brown colour, its specific gravity being then about 1. Whilst it is insoluble in water, not affected by time or exposure to air or moisture, it congeals at about 42° Fahrenheit; and in the open air or mere ordinary packing, it will burn without exploding. Indeed, there are only three known methods of exploding it: 1stly, by a violent explosion, either in it or into it; 2ndly, by confining it in a very strong and tight vessel, and setting it on fire, or heating the vessel sufficiently; 3rdly, by a percussive shock, so as to produce heat and violence equivalent to an explosion. It may be here remarked that, unlike gunpowder, the explosion is entire and instantaneous, the whole mass going off as if it were a single grain, which quality, combined with the extraordinary evolution of gases, tends to prevent its use in firearms or ordnance, the

guns being blown to pieces instead of being merely discharged. Further researches and improvements may, however, we incline to think, discover the means of so mitigating these conditions, as to bring the wonderful power of this explosive under the control of our artillerists. Some extremely interesting experiments have been made with dynamite, the consumption of which in California amounts already to between 12,000 and 15,000 pounds per month at San Francisco, as well to show when this powder will not as when it will explode, and we much wish we had room to give them all to our readers. Indeed, its non-explosion appears to us even more extraordinary than the cases in which they take place. We give just one instance:—A box of half-inch pine boards was filled partly with cartridges, and partly with loose giant powder. A common fuse, without any cap, was inserted in the loose powder, the cover of the box screwed on, and the fuse lighted. The loose powder was set on fire, causing a formation of gases, which forced the boards apart, and escaped with a hissing noise like steam. There was no explosion. The loose powder was burned, whilst the cartridges were unaffected except by being scorched. In this state one of the cartridges was taken from the box, and exploded in the ordinary manner with terrific effect.

The next of the new explosives with which we have to deal is dualin, the invention of Lieutenant Dittmar, of Boston, which is a mixture of nitro-glycerine and nitrogenized cellulose, made from sawdust. It was first introduced into Germany in 1869, and is largely used in the mines belonging to the Prussian Government, where it has taken the place formerly occupied by common powder, nitro-glycerine and dynamite. We may sum up shortly its especial advantages by saying that, being fifteen times the strength of common powder, it is therefore stronger in relative proportion to the other two explosives we have been considering. It would appear also to be stored, transported, manipulated, and applied with fewer risks than common powder. Its explosion does not develope noxious gases, and the effect of them is to tear and rend the material exposed to their action rather than to pulverize them as does nitro-glycerine. It is also cheaper than this last named.

A quantity of this explosive appears to have been used in the great Hoosac Tunnel, and the contractor, Mr. F. Shanly, is of opinion that in its results it is "fully equal to nitro-glycerine, whilst for safety in handling it is vastly superior." Passing over the further advantage it possesses over dynamite of not freezing, it may be noted that, whilst some writers claim for the latter the quality of not being liable to become moist, on the other hand, the inventor contends that dualin is insensitive to moisture.

Mr. Blake further refers to pyroxyline, xyloïdine, and gun-cotton; to Oliver's powder, the principal feature of which appears to be the substitution of peat for charcoal—a substitution the value of which must clearly very much depend upon the constituent materials of the peat, which, so far as our experience goes, vary even more than do those of tree or bush charcoal; and also to the chlorate of potash powder—this last powder, composed of chlorate of potash, sulphur, and carbon, was experimented upon by Berthollet, so early as 1788, but it and the mixtures of the chlorate with white sugar and prussiate of potash and with charcoal and sulphuret of antimony and starch, have been found so dangerous, either to manufacture or to transport, that for the present at least they need scarcely be noticed as coming practically before the world, any more than does the picrate of potash, the fearful accident caused by which at the Sorbonne in 1869 is probably within the recollection of many of our readers.

Here, then, we leave the explosives, and turn, just for the little space we have left at our disposal, to the question of exploding charges by electricity, as it is treated by Mr. Blake. Under this head, however, we find merely a few words on Stowell's patent (1862) for a form of cartridge containing the ends of the conducting wires and a strip of platinum; a mention of Beardslee's mode of making an imperfect conductor between the ends of two wires, by drawing a pencil mark of graphite, upon the surface of a piece of dry wood; and of Mowbray's patent (1869) for an electrical fuse, consisting of a cartridge of powder, on the top of which is placed a small quantity of a composition made of sulphide of copper, 9 parts; subphosphide of copper, 2 parts; chlorate of potash, 3 parts, the whole intimately mixed—the ends of the wires being immersed in the mixture. The fuse is especially designed for insertion in cans of nitro-glycerine to be exploded in oil wells. The last portion of this part of the volume before us is devoted to the description of an electrical machine invented and patented (1869) by Mr. H. J. Smith, for which he claims thorough efficiency in a damp atmosphere—this efficiency being obtained by the use of a vulcanite generating plate—the whole instrument consisting of an outer covering or shallow box, containing a frame plate, a Leyden jar or condenser, a generating plate of vulcanite, and certain devices for operating the generating plate and condenser in connection.

In Section II. Mr. Blake treats of Boring and Excavating by Machinery; of machines for drilling rocks he says they "originated in the United States, where one was put into practical operation as early as 1838. The attention of mechanicians and inventors being thus early directed to this great desideratum, a machine that could be economically and easily substituted for hand labour, so great a variety of contrivances and forms have been proposed and experimented with, that their number renders it difficult even to enumerate them. Our patent office and the patent offices of Europe contain many models of machines; but most of them are of the class known as 'drop drills,' where the tool cuts by percussion. There are other forms of machines, fitted with revolving disks or cutters, and designed to bore out the drift or tunnel to its full size at one operation; and others, again, in which a number of drills are mounted in a frame, so as to cut an annular space around a central core of rock, which can afterward be broken out with powder or otherwise. There is still another type, in which diamonds are made to do the cutting by pressure and rotation, without percussion. Rock-drilling machines may therefore be grouped in two great classes: 1. Those that bore by percussion; 2. Those that bore by constant pressure and rotation.

The drop drills belong to the first class, and will be first considered. In these machines the drill or bar of iron or steel—either a single rod or provided with a steel bit or point at the lower end—is raised by means of a crank, cam, or other mechanism, and then allowed to fall by its own weight upon the rock to be bored. There are also numerous contrivances to accelerate the speed of the fall and increase the force of the blow. Metallic and rubber springs have been used, and, in some cases, the elasticity of air; but in all these modifications but little has been gained over the form in which gravity acts unaided. With springs, the greatest compression and force is exerted when the drill is at its highest or furthest from its striking point, and as the drill descends this force becomes less and less—the reverse of the most desirable condition given by gravity.

It is desirable to note a few of the more important of these inventions which have been in use practically during the past thirty years, and which, by successive modifications and improvements, have led to the present very considerable degree of perfection of rock-drilling machines.

As early as 1838, Messrs. J. M. and John N. Singer experimented with a large drop drill on section 64 of the Illinois and Michigan Canal, about thirty miles below Chicago. This machine was patented in May, 1839, and some ten or twelve machines were built for, and used upon the canal until the suspension of that work in 1841-'42. They were also used in the Mount Washington cut, near Hinsdale, for the Western railroad of Massachusetts. Two machines were built at Lockport, in 1840, and used upon the enlargement of the Erie Canal. Modifications of these machines are even now in use in various parts of the country. They are all drop drills, and their operation is restricted to vertical holes.

The original Singer drill, as applied in Illinois, is considered to have been the first successful machine for its purpose. It was extensively copied, and many improvements upon it were claimed from time to time. The first substantial departure from it was made by J. J. Couch, aided by Joseph W. Fowle, of Boston, in the year 1848. They constructed a steam drilling machine in which the drill-bar passed directly through the piston of the engine and was alternately caught, drawn back, and thrown against the rock. It was only used a short time in experimenting, and was finally taken apart and sold at auction. Although not a success, this machine marks the second phase of the rock-drilling machines, and was the first attempt that approached success in the direct application of steam-power to rock-drilling.

From the time of this experience the two inventors separated, Mr. Couch following up the general idea of a hollow piston drill, while Mr. Fowle, discarding the idea of the hollow piston, conceived that success would be gained by placing the drill directly upon the end of a solid piston-rod. During a period of five years Mr. Couch produced a number of drilling engines, variously constructed, but all upon the hollow-piston plan. Some of these were in a measure successful, but not sufficiently so to insure their general adoption. They required very nice adjustment and presented practical difficulties; and finally this style of machines was abandoned.

Mr. Fowle, adhering to his plan of attaching the drill directly to the piston-rod or cross-head of an engine, experimented and struggled against many obstacles for several years. He built, in all, some five machines, but did not succeed in carrying his plan to perfection, until, discouraged and disabled by sickness, he suspended his efforts.

In the year 1861 machine drilling was experimentally begun by Sommeiller, at Mont Cenis, with machines virtually upon the principle of Fowle's, though different in construction. To M. Sommeiller belongs the credit of driving such machines with compressed air, a very important application of this power for all tunnel or mining work, especially where artificial ventilation is required.

The magnitude of the undertaking to tunnel the Hoosac Mountain, in Massachusetts, upon the line of the Troy and Greenfield Railroad, prompted the commissioners having it in charge to seek all means of accelerating the work, and their attention was naturally directed to the reports of rapid progress by machine drills at Mont Cenis. The report being favourable as to the results, while the machine of Sommeiller was not regarded as specially adapted to the work on the Hoosac Tunnel, it was decided to devise and perfect a drill for the purpose. As a first step, Couch's patent of the hollow piston-rod was purchased for New England, and scientific mechanics were employed to work upon it. One of these machines, constructed by Mr. Hanson, is known as the 'Hanson Machine Drill,' which promised some success, but on trial proved a failure. It had a cylinder and valve-motion, similar to those of a steam-engine. The piston was hollow, with the drill-bar of any required length, passing through it and moved by the piston, by means of four wedges or cams at each end. These cams were pressed upon the drill-bar by means of sliding collars, forced upon them by a complex arrangement of mechanism, acting alternately upon one and the other, for the purpose of catching and throwing the drill-bar. The rotation of the bar was effected by means of a ratchet, worked by a spiral groove in the shield of the machine. There were 120 pieces in this machine, and it weighed 590 pounds. It did not work well horizontally. The main difficulty was with the cams and collars for seizing the drill-bar.

A second machine, called the 'Brooks, Burleigh, and Gates Machine,' made under the direction of the commissioners at Fitchburg, was put upon the works and used for several months. This machine also had a hollow piston, the drill-bar or holder being a screw, passing through the piston and moving with it. The feed was given by means of a nut on the end of the piston-rod, held by means of a cap or union nut, the latter being screwed on to the coupling, and the coupling-nut screwed to the piston-rod. The feed nut turns in the union nut, and protrudes from it. A ratchet, moving with the piston, works upon this feed nut, and is governed in its action upon the nut by a spiral groove in a shield attached by screws to the cylinder. On the ratchet band there is a pawl, with two springs, one under the other; one serves to hold the pawl in gear, the other to hold it out of gear. As the piston descends, the outer spring comes in contact with a trip on the shield, and is lifted up, allowing the under spring to throw the pawl into the ratchet; and as the piston returns, the outer spring turns the nut round, and thus feeds the screw, or the drill-bar, forward. At the end of the back stroke, the pawl strikes another trip on the shield and is thrown out of gear, and is held so by the outer spring, made with a catch. The rotary motion of the drill-bar is given by a ratchet on the coupling-nut, covered by a ratchet band, the arm of which moves in a spiral groove in the shield, similar to the other. The crosshead is held between two check-nuts, on the coupling nut. It carries a bar, governing a valve which opens the port when the piston and drill-bar move back, and shuts it when they move forward; the air is always pressing during the backward stroke. The area of the back of the piston being greater than the front, the forward pressure preponderates and carries the piston forward, and when cut off the backward pressure returns the piston.

The piston-head of this machine has a diameter of $4\frac{5}{8}$ in. and the diameter of the piston-rod is 4 in. at the large end and $2\frac{1}{4}$ at the small end. There are, therefore, 12·87 square in. of area on the back, upon which the compressed air acts to drive the drill forward against the rock, and 4·23 inches area on the forward end upon which the air acts to throw the drill back out of the hole. As the pressure was not removed from the front of the piston, the motion forward was due to the difference of area between the back and front of the piston, viz., $12{\cdot}87 - 4{\cdot}23 = 8{\cdot}64$ square in.

This machine was automatic, and it generally continued to work until some part gave way. No part of it was found to be strong enough to withstand the shocks for any considerable portion of time. The union nut was its weakest point; and the breaking of this nut generally destroyed the part of the piston to which it was attached. The springs of the feed ratchet-band were also almost continually breaking.

This machine had 80 pieces; of these 23 were screws, 15 pins, and 7 pieces of cast iron. It weighed 240 pounds, made about 200 strokes per minute, and cost about $400. Its longest run without breaking, was five days. To run for two days without breaking some part of the machine was considered fortunate. More than one breakage a day was the average.

The experience with these machines at the Hoosac tunnel was discouraging. About forty machines were used there, and of these, eight or ten were originally vertical, and intended for use in sinking the central shaft. Owing to the many breakages it was difficult to keep up a supply, and the progress of the work diminished in proportion to the giving out machines. It was the opinion of the engineer that if a constant supply of machines could have been furnished, the progress would have been much greater than that attainable by hand labour. The average 'life' of one of these machines was about eighty hours, and it is said by those familiar with the operations at the tunnel at that time, that soon after starting them at work, the tunnel seemed to be a highway, along which a crowd of people was continually passing, each person carrying a portion of a drilling machine, or tools and materials for repairs.

This unsatisfactory experience led to the gradual abandonment of the Brooks, Burleigh, and Gates machine, and the substitution for it of a new and simpler machine, made by Mr. Charles Burleigh, called 'The Burleigh Rock Drill.'

Abandoning the idea of constructing a machine upon the Couch or hollow piston principle, Mr. Burleigh purchased the Fowle patent, and commenced the construction of machines with solid pistons, arranging the details of construction so that the parts should be few in number, and strong enough to bear the great shocks of working. In this he claims to have been successful; and it is stated that sixteen out of the twenty machines furnished for use at the east end of the tunnel were still in operation at the close of the summer of 1869, some of them having been in use since November, 1866.

According to a report made by a joint committee of the Massachusetts legislature, the construction of this drilling machine, in 1867, was substantially as follows: It has a solid (so-called) cast-steel piston, to one end of which the drill or bit is attached, while the other end within the cylinder, by means of suitable mechanism, operates the valves. The piston-head has a diameter of 4·25 in.; the piston at the large end 3 in., and at the small end, 2·75 in. The number of inches of air area is thus 8·20 when the drill is thrown out upon the rock, and 7·07 when returning. On the back end of the piston is a section of a ball used as a cam, which works the valve and the feed motion. The movement of the piston brings the ball into contact with these cams, and, by rocking them back and forth, opens and closes the valve. The cylinder is supported upon parallel ways or a bed-plate, upon which it slides up and down as moved by the feed-screw. This feed-screw passes through a gallows frame, attached to the upper end of the ways, and the lower end of the screw, passing through a feed-nut, enters the cylinder. The end of the piston is drilled out, so that the feed-screw is not struck during the oscillations. The feed-nut is secured between two collars, so that it turns easily, and its outer edge is cut into a ratchet, into which works a pawl, operated by the piston, turning the nut upon the fixed feed-screw, and moving the cylinder, drill, &c., forward. This machine weighed 372 pounds, including the ways or bed-piece; without the ways, the weight was 212 pounds. It comprised eighty pieces, and had the same number of screws and pins as the Gates, Brooks, and Burleigh machine. Its number of strokes was 300 a minute. They stood the work much better than the former machines, and their average 'life' in the tunnel without repairs was about five days. One worked for fourteen days without repairs.

The Burleigh drilling-machine as now made is simpler and stronger than the machine of 1866. It has 27 pieces less than that machine. Five sizes are made, drilling from $\frac{3}{4}$ in. to $5\frac{1}{2}$ in. holes, and feeding from 30 in. to 84 in. without change of drill points. The piston-bar, to which the drill-point is directly attached, is made of solid cast-steel. The machine is so constructed that the piston-bar is the only part of the machine which receives the shock resulting from the blow upon the rock. With a pressure of 50 pounds to the square inch, the drill strikes from 250 to 300 blows per minute. It weighs from 150 to 1,000 pounds, according to size, and can be operated either by steam or by compressed air. The size recommended for general mining is the tunnel size, weighing about 400 pounds, drilling $1\frac{1}{4}$ to $2\frac{1}{4}$ in. holes, and feeding 36 inches without change of drill-points. It will drill from 2 to 6 inches a minute, according to the hardness of the rock.

Besides being in operation at the Hoosac Tunnel, these machines are or have been in successful working operation in New York, Chicago, Jersey City, Hell Gate, Scranton, Lake Superior, Colorado, Nova Scotia, Union Pacific Railroad, Boston and Hartford Railroad, &c., and in deepening the beds of the Illinois and Michigan Canals at the Des Moines Rapids.

In Colorado, Mr. Burleigh is running a tunnel to intersect

several lodes at a considerable depth. It is found advantageous to make this tunnel larger than is usual, in order to have room for the machines and two tracks. It is, therefore, cut 8 ft. high and 9 ft. wide. A double track is laid with iron rails as the work advances. Two inside shifts of men, four in each, are worked regularly; and with the drilling machines the progress in a hard crystalline rock has been, of late, as great as 60 ft. per month. In one week, 15 ft. of advance was made, and at a cost per foot of $37 50c. including all expenses. The tunnel has now penetrated 415 ft. in the solid rock, and the average rate of progress for some months before the machines were carried to their present degree of perfection was 40 ft. per month, which was at least four times as great as could be accomplished by hand labour. The expenses of running a tunnel in Colorado, near Georgetown, are much greater than at the East. Miners' wages are $4 per day; blacksmiths', $6; powder, $8 per keg; wood from $5 to $6 per cord, and all supplies are costly. The cost of driving the tunnel up to March, 1870, had been $62 per running foot; which is much less than it would have cost by hand labour alone.

The Baltimore Tunnel, in the vicinity, is being driven with three shifts, of three men in each, at a rate of 50 ft. per month. Another tunnel, worked by hand labour alone, is advancing only 8 ft. per month. Mr. Burleigh thinks that he can drive the large sized tunnel more rapidly and cheaply than one of the ordinary dimensions.

At Hallett's Point, near New York, these drills have been advantageously used; and it is believed that they accomplish from three to four times as much as can be done by hand for the same cost, and in much less time.

At the Hoosac Tunnel, (January, 1870), the Burleigh drills are used in driving the 'headings' only at both ends of the tunnel —nine machines at the eastern end and eight at the western end. The heading or advanced opening is 8 ft. high and 24 ft. in width; and in the eastern end is made on the floor, and in the western end, next the roof. The enlargement is at present carried forward entirely by manual labour; but arrangements are being made for the use of the machine drills for the enlargement of the eastern end. The rock is a compact mica slate, in which, at the western end, veins of quartz, sometimes many feet in thickness, are of frequent occurrence. In the eastern end, however, the mica slate is comparatively free from these veins or bands, and the rate of progress there is much greater.

In the western end eight drills are kept constantly at work. Four drills are mounted upon a carriage, which, with its load of drills, tools, &c., weighs by estimate about 5 tons. There are two carriages, which are brought into position upon parallel railways, laid as the work progresses. The holes are commenced with 2 in. drills, and finished with $1\frac{1}{4}$ in. drills, or drills which cut holes of those diameters. The average depth of the holes is about 50 in. At the western end, where the quartz veins are so frequent and hard, the working of the drills is so constantly interrupted by stoppages that it would require very extended observation of one machine to determine the work it is capable of performing. One of the machines drills about twelve inches in ten minutes, making, as nearly as can be estimated, something over 200 strokes per minute, the rock drilled consisting largely of quartz. In boring a hole 5 feet in depth in such rock, the drills are often changed as many as ten times. According to Mr. Roscoe, manager of the western end of the tunnel, one of the new drills had drilled a hole 5 ft. in depth in quartz rock, such as frequently occurs there, in 25 minutes. At the eastern end, where the rock is mica slate without the heavy quartz veins, a hole of equal depth is often drilled in from 10 to 12 minutes. According to Mr. Shanly, from 800 to 900 in. are drilled in the western heading during every shift of eight hours; and the daily progress of the tunnel is about 4 ft. In the eastern end, however, with nine drills, from 1,600 to 1,800 in. are drilled every shift, and the daily rate of progress is about 6 ft. Blasting is done twice in every shift.

It is the opinion of the superintendent that in the eastern end the cost of drilling by the Burleigh drill is to the cost of drilling by hand as $4\frac{1}{2}$ to 7. In the western end, however, it is believed that the machine-drill, owing to the numerous stoppages, is as expensive as it would be by hand.

Each drill requires the constant attendance of two men. In hard rock it is found necessary to feed the drill by hand instead of employing the automatic arrangement provided for that purpose. Hence, at the western end, where the rock is so highly quartzose, the feeding is done entirely by hand; but in the eastern end, where the rock is less hard and of more uniform character, the feed is automatic.

At both ends the wear and tear on the machine-drills is necessarily great; but in the western end particularly so—so great, in fact, that on an average two drills are in the shop for repairs to one at work in the 'heading.' But this end had not been fully supplied with the *new* Burleigh drills.

As before stated, these drills may be operated by either compressed air or by steam. For all underground operations the former is used. At the western end of the Hoosac Tunnel four of Burleigh's air-compressers are used for the compression of air to work the drills. The compression is rapidly effected by pumps, worked by a steam engine.

The reservoir at that place consists of two cylindrical vessels of boiler-iron, 25 ft. long and 5 ft. in diameter, in which the compression is carried to from 50 to 60 pounds to the inch, or from three and one-third to four atmospheres. The air is conveyed in iron pipes 8 in. in interior diameter."

Mr. Blake then exhaustively reviews the various kinds of drilling machinery in use, including a very interesting description of the diamond annular drills, concerning which he says it is probable that they "may be advantageously used for cutting shafts of large diameter, inasmuch as the ratio of the quantity of material cut away to the size of the hole bored becomes less and less as the size of the bore increases. A large core would be left, but this could be readily broken up by blasting in a central hole. Among the great advantages of such shafts would be their truly cylindrical form and smooth sides."

The next subject with which our author deals is boring for deep wells, in which chapter is described the means used by Messrs. Degousée and Ch. Laurent, in boring the artesian well of La Chapelle; among others, a trepan, weighing about 4 tons, which cut out an annular channel of ·45 to ·50 m., leaving a core of ·80 to ·90 m., thus producing a shaft of 1·90 m. in diameter; this well is tubbed with a casing of sheet-iron. Mr. Blake then explains to us the methods employed for boring large mining shafts, including M. Chaudron's method of lining the shaft at L'Hôpital, and lowering the lining into its place, which he contrived by means of a temporary convex flooring to the cylindrical lining, and thus floating it on the water in the shaft, regulating its descent by means of a tube pierced with holes, inserted in the centre of the temporary flooring, which allowed the water to rise in the cylinder, and thus sink it at the will of the workmen.

We are next introduced to coal-cutting machinery, where the following machines, among others, are described.

"Coal-cutting Machine of Messrs. Jones and Levick.—This machine may be described as a contrivance for holding and swinging a miner's pick so as to undercut a coal-seam nearly as it is done by hand. It is actuated by compressed air, and is mounted on a carriage or truck with four wheels, with an extended cast-iron platform in the rear for the man who works the machine. A crank-pin on a fly-wheel actuates two bevel-wheels for moving the machine back or forwards on the rails of the gallery.

The handling of this machine is very simple. The workman on the platform turns a wheel so as to bring the pick into the proper direction; he then opens a cock admitting compressed air into the cylinder by working the slide with a lever. The machine being thus set in motion, it is merely requisite to move it forward to follow up the work done by the pick. The air, on leaving the cylinder, escapes freely into the gallery.

We subjoin the reported results of experiments made by this machine in two mines in England:

In the High Royd colliery, in a hard coal, and in a gallery in which the rails were in a bad state, with an air pressure of from 2 to $2\frac{1}{2}$ atmospheres and 70 to 80 blows per minute, the average hour's work of the machine was a channel from $8^{m}{\cdot}20$ to $9^{m}{\cdot}15$ long and from $0^{m}{\cdot}90$ to $1^{m}{\cdot}00$ deep, including stoppages. The width at the bottom was $0^{m}{\cdot}037$, and on the face $0^{m}{\cdot}08$. During ten hours' consecutive work, the work produced by this machine was equal to that of twenty miners during the same time; and it appears that the consumption of air is equal to about three horse-power.

Firth's Patent Coal-cutting Machine.—This is also a percussive machine, and is worked by compressed air. It is mounted upon wheels which run upon rails on the floor of the mine. A pick is attached at the forward end of the machine to the lower end of a vertical shaft, and a horizontal swing or sweep is given to it by means of arms and levers connected with the piston-rod. In its form and mode of operation, this machine somewhat resembles the preceding. Some improvements in this machine have been reported recently. It is stated to be working in the seam known as the 'Little Coal,' which is 2 ft. 8 in. thick, and to have undercut a face of 500 yards in length to a depth of 3 ft., using a new form of the pick which removes the dirt as it proceeds.

Mr. Firth has also recently invented a method of fitting picks with movable cutting points. It is the general custom to work picks with points solid; that is, the point and pick in one piece. By this arrangement it becomes necessary to take the whole pick out of the pit whenever blunted, in order that it may be sharpened. The improvement consists in making a boss on that part of the pick nearest the point. In this boss is a socket

of any suitable shape, by preference a circular taper socket, the loose point being cottered into the socket against a piece of indiarubber, or other suitable substance, at the bottom of the socket or around the outer edge of the socket, so that when the blow is given some part of the strain is taken off the point. The edge of the socket is brought as close as possible to the point, for as the socket must enter the groove made in the coal, and must be clear of the top and bottom of the groove, and as in some cases the groove is not more than 1¾ inches in height, it will be readily seen that the closer the socket is to the point, the greater the resisting strength of the point."

From the notice of pumping appliances we extract the following account of the great pumping engine of Grand Hornu, which "was constructed at the works of Seraing, for a shaft 460 metres deep. It works a series of eight plunger-pumps and two lifting pumps of $0^{m}{\cdot}50$ in diameter, and four metres stroke. These pumps are placed one above the other, at distances varying from 30 to 60 metres. The upper plunger-pump, 60 metres from the surface, is worked by a double rod, each arm having a square section of $0^{m}{\cdot}484 \times 0^{m}{\cdot}242$, and being formed by the juxtaposition of two pieces o $^{m}{\cdot}242$. These rods are completely enveloped in iron $0^{m}{\cdot}024$ thick. The double rods gradually diminish in size toward the bottom of the shaft, but in each section the weight exceeds that of the column of water to be thrown out. The total weight to be counterpoised is 200,000 kilogrammes; and this is effected by two balance beams mounted upon opposite sides of the master-rod, directly below the engine.

The engine is direct-acting, the cylinder being mounted directly over the shaft. It has three floors or stages: 1. The cylinder; 2. The condensers, with their air-pumps; 3. The balance beams. The cylinder is jacketed to prevent condensation. It is $0^{m}{\cdot}05$ thick, and is made in two pieces, each $1^{m}{\cdot}60$ high. There are three valves: the admission valve, $0^{m}{\cdot}42$ in diameter and rising $0^{m}{\cdot}06$; the equilibrium valve, $0^{m}{\cdot}51$ in diameter, and rising $0^{m}{\cdot}08$; the exhaustion valve, $0^{m}{\cdot}60$ in diameter and rising $0^{m}{\cdot}85$. The condensers have a diameter of $1^{m}{\cdot}20$, and are $2^{m}{\cdot}50$ high. The air-pumps are $0^{m}{\cdot}95$ in diameter, and have a stroke of $2^{m}{\cdot}10$. The balance beams are $11^{m}{\cdot}40$ long, and each carries 90,000 kilogrammes of counter-weights, formed of plates of cast iron."

In the chapter on safety lamps, Mr. Blake gives us the details of experiments carried on to ascertain the security afforded by the Davy and Stephenson safety-lamps, which resulted in demonstrating the comparative safety of the Stephenson models over those of Davy; at the same time proving that great care should be bestowed on the construction as well as repair of these lamps. He says:—

"From these and other well-known facts, it will be seen that safety lamps, in mines containing explosive gases, afford a relative security only. This was, perhaps, never more strikingly (and harmlessly) shown than in an incident which occurred some years ago, in Zwickau, Saxony.

A lecturer[1] had been explaining the principle of the safety lamp to a considerable audience, and proposed to illustrate his remarks with an experiment. For this purpose he had prepared a simple apparatus, consisting of a large glass jar and a rubber pipe with a glass elbow at one end. The other end of the pipe was connected with a gas fixture; a safety lamp was set inside the jar, and the bent glass nozzle was introduced to the bottom of the lamp. The lecturer remarked, that upon turning on the gas, an explosive mixture of carbureted hydrogen and common air would be formed in the jar; the flame of the lamp would be elongated, and a long blue tip would be seen; then the whole interior of the wire-gauze cylinder would be filled with flame; but, though the gauze might become red hot, the flame could not, in any case, strike through to the outside—all of which phenomena, positive and negative, would be clearly visible through the transparent jar. The gas-cock was thereupon opened, but instead of the peaceful demonstration looked for, a prompt contradiction of the theory was the result. The flame was communicated almost instantly to the gas outside of the lamp. In some confusion, the lecturer repeated the experiment, but with the same result; and he finally gave it up, confessing his inability to explain the disappointment, except on the hypothesis of some unknown imperfection in the lamp. The occurrence made a good deal of stir, particularly as there are many coal mines in the Zwickau district troubled with fiery gases, and at that time recent accidents had been occasioned by explosions in spite of safety lamps. The test was therefore repeated, still more publicly, upon some sixty lamps of various patterns, and it was found that only the old-fashioned Davy, and one other, the name of which escapes us, would retain the flame. Those lamps were found to be particularly dangerous which possessed separate openings below for the admission of air to support the flame.

These experiments indicate the same conclusion as was lately arrived at by English investigators, namely, that the strength of the draught of inflammable gases through a safety lamp has much to do with the degree of its security. The Zwickau lamp may have been unusually faulty in construction, rather than principle; but this fact, though it might lessen the importance of these special experiments, could not alter the general bearing of both practice and theory on the question of the safety of all lamps. The principle involved is that of the rapid conduction and radiation of heat by the wire of the gauze surrounding the flame. Before the burning gas can pass through the meshes, it is said, so much of its heat will have been abstracted, and radiated away in all directions, that it will fall below the temperature of ignition or explosion. Now, this depends upon the amount of heat communicated to the wire in a given time. The wire may get hot faster than it can grow cool again, and if this increase of temperature is carried to a white heat, the gas outside will be set on fire. But the amount of heat given to the wire in a certain time depends again on the amount of burning gas that passes through it in that time, and hence it is clear that a strong current of gas may overheat the wire and cause an explosion. The Davy lamp is not constructed to favour a strong current. Indeed, one complaint of it has been the feebleness of the light, from insufficient air. It appears, however, that attempts to remedy this deficiency are fraught with peril.

We desire to call the attention of engineers to the great simplicity and conclusiveness of the test above described, and to urge that it be at once applied to the lamps of every mine. There can be no harm in knowing whether the lamps will do what is claimed for them. It is true that common illuminating gas forms with common air a more explosive mixture than does the fire-damp of mines; but the severity of this test ought to be nothing against it, so long as any lamp can be found to bear it.

In the general dissatisfaction with the use of safety lamps, which spread through the Zwickau district after the experiments alluded to, a new and bold plan was suggested, and has been carried out in several cases with the best success. This was nothing more nor less than *to burn naked lights in great numbers* wherever inflammable gases made their appearance. Some of the workings presented, under this system, an unwonted appearance. In one case, the fire-damp could be heard streaming out of the fissures of the coal, with that peculiar humming sound which the miners know so well and fear so greatly; the innumerable lights carried each a long blue tip—the usual signal of danger—yet no harm occurred. The gases were quietly consumed as fast as they entered the mine, and the illumination was carefully kept up, night and day, Sundays and between shifts, that no opportunity was given for an accumulation of explosive material.

The great difficulty of this plan is its direct injurious effect on ventilation. The stationary lights with which the mine is crowded, in addition to those carried by the workmen themselves, must necessarily use up a good deal of oxygen, and produce a good deal of carbonic acid. But this is an evil which can be combated in other ways, and, at all events, it is preferable to the danger of explosion. Perhaps it might be an improvement to use safety lamps instead of naked lights, hanging them in great number along the walls, so as to secure the complete, quiet combustion of the gas. But it must be confessed that, even under circumstances of the greatest danger, the naked lights have done very well, and no accident, so far as we are aware, has ever resulted from their use in this way.

Propositions have been made to explode the accumulated gas in workings before the workmen are allowed to enter them. In a rude way, this has frequently been done in fiery mines; and to remove all personal danger, it is now suggested that the explosion be effected by means of a battery. But this whole system of allowing the fire-damp to accumulate while the workmen are absent, and then firing it off all at once, strikes us as much inferior to the simple expedient of burning it gradually, as above described."

[1] Mr. A. Mezger, mining engineer.

GEMS OF INDUSTRIAL ART.—ENCRUSTED ENAMELS.

By Christofle and Co.

LEATHER: AT BERMONDSEY AND AT THE EXHIBITION.

IT is one of the small misfortunes of our railway system in London that nearly all distinguished foreigners—czars, shahs, sultans, kaisers, emperors, kings, princes, grand-dukes, archdukes, rajahs, nabobs, ameers, khans, and illustrious ladies—must pass through a very ill-odoured district before they can reach the queen's city or the queen's palaces. We call it a small misfortune, and it is small; still we should prefer that those who honour us with a visit should not have to encounter an ordeal very much like that of the "two and seventy stinks" which Coleridge declared he could discriminate at Cologne.

Bermondsey in the Old Times.

The district we speak of is Bermondsey. Of course there is no absolute necessity for taking this route to the great metropolis. The distinguished foreigner, landing at Dover, may follow the Chatham company's route to Victoria; or, making Harwich his place of debarkation, may wend to the Great Eastern terminus; or, landing at Southampton, may find his way to Waterloo; or, setting his foot on English ground at any of the western or northern ports, may enter London by Paddington, Euston, St. Pancras, or King's Cross. But it does so happen that most of the visitors of whom we are speaking land at Dover or at Gravesend, travel by the South Eastern line, and set down at the Charing Cross terminus. When once they have passed New Cross there is no escape from it; go through it they must—through a region which, in days of yore, was pleasantly occupied by market gardens, but which is now dotted all over with manufacturing establishments, grimy to look at and unwelcome to the olfactories. There are, it is true, a few really magnificent structures, devoted to perfectly healthy and interesting branches of industry; but it is not the less true that Bermondsey and Rotherhithe abound in places where very unlovable processes are carried on. The manufacturers and their men cannot be clean at work, cannot make their labours inodorous or pleasantly odorous, try as they may; and, as they carry on very useful trades, we must not sentimentally find fault with them. All we mean is to express a little regret that this particular line of railway should happen to pass through this particular district.

It is tempting to look at the names hereabouts, but disappointing to find how woefully they have lost their original meaning. Cherry Gardens, where is the garden, where the cherries? and Marygold Street, how long ago did it possess flowers? Manor Road, but no manor house; Alderminster Road, but no minster; Grange Road, but no grange; Willow Walk, but no willows; Page's Walk, but no walk that anyone would care about, and no page whether we want him or not; Abbey Street and Star Corner, without either abbey or stars; College Street, innocent of a college; the Maze, without other labyrinth than that of dirty houses; and Snow Field, where there is no field for the snow to rest upon.

The truth is, Bermondsey was once an interesting place, long before dirty manufactures settled there. There was a magnificent ecclesiastical foundation, the Abbey of Bermondsey; and hence the origin of many names of roads, &c., which have now no meaning. As to the name of the district itself, the best authorities trace Bermondsey to *Beormund's Ea* or *Eye*, Beormund being a Saxon lord of the manor, and Ea or Eye being a marshy or watery spot, with probably a dry islet in the middle, on which the manor house or residence was built. Hence the names manor, grange, &c. Many facts tend to support the view that Bermondsey was at one period a network of marshy islands when the tide was out, and an expanse of water when the tide was in; but this must have been long long ago, since which time much must have been done in the way of embanking and draining. Henry II. held an important meeting of nobles at the abbey; the sister of Queen Matilda and the murdered Duke of Gloucester were interred there; Katherine, the French queen of Henry V., ended her days in the abbey; as did Elizabeth Woodville, queen of Edward IV.—more as a prisoner than a guest. Henry VII. made a strange compact with the City of London, the Abbot of Westminster, and the Abbot of Bermondsey; to the effect that Westminster was to pay the sum of £3 6*s.* 8*d.* annually to Bermondsey for the holding of an annual solemn ceremony. The ceremonial, rich in its accessories, was for the good and prosperous estate of the king during his life, the repose of the souls of his queen and their departed children, and for the future welfare of others of his relations still living. Henry VIII. put an end to the abbey, and absorbed its revenues; after which the estates were bandied about among peers, baronets, and courtiers of various kinds; while the venerable structure disappeared bit by bit, until there is now probably not a scrap of it left.

Modern Bermondsey and its Industries.

What old, old world associations are these; let us quit them, and look at modern Bermondsey with its leather.

Leather indeed! Tanners, curriers, leather dressers, leather dyers, leather embossers, leather enamellers and japanners, leather factors, hide and skin brokers, hide and skin merchants, fellmongers, parchment makers; and, as users up of refuse, glue makers, manure makers, and tan-turf makers. Notable among them all is the inevitably dirty trade of the fellmonger, whose office it is to loosen the hair and wool of hides and skins by putrefactive fermentation in order to facilitate their removal from the pelts or membranes which are to be tanned. When the supply of water by companies was unknown, Bermondsey was intersected by many streams, which were filled at high tide; and there is reason to believe that the trade of tanning or leather making—an eminently sloppy one—settled in that locality on account of the good supply of water. One of these small streams was called the Neckinger—a name perpetuated in the Neckinger tannery and the Neckinger Road, although the stream itself has we believe disappeared.

The Hide and Skin Market of Bermondsey may be regarded as the nucleus of the trade, locally as well as technically. Wool is manufactured by processes widely different from those of leather, and applied to widely different purposes; but the two are intimately allied nevertheless. When country killed meat is brought to London, and sold at Smithfield Meat Market, the hides and skins are mostly left in the country, to be dealt with by provincial fellmongers and tanners. When, however, live stock are brought to London, and sold at the Pentonville Cattle Market, Bermondsey has much to do with the result. Skin salesmen, acting as agents between buyers and sellers, effect a transfer of the sheepskins from the licensed slaughtermen to the fellmongers, and of the bullock and calf skins to the tanners. The salesmen, collecting the skins from all quarters, take them to the Hide and Skin Market, and spread them out on plots of paved yard well prepared for the purpose; in a brief space of time the fellmongers and other manufacturers clear off the whole supply, and cart away the skins to the factories round about. Whether the tanner purchases the ox, cow, calf, and horse hides direct from the slaughterers, or through the medium of a salesman; whether bought at the Bermondsey Market or elsewhere—are questions of trade convenience; but nearly all the sheep skins find their way to the market.

The home supply is far from satisfying the wants of our tanners and leather dressers. South America sends us largely of its ox hides, for heavy solid boot leather; the useful kinds known as kips come from the same region, and also from India, Russia, and Greece; Denmark, the Cape of Good Hope, Spain, and Holland contribute to our wants; goat skins come chiefly from North Africa, such as Morocco; kid skins from South Europe; sealskins from Newfoundland; and other varieties from various parts of the world.

The Philosophy and Materials of Leather Making.

It is neither necessary nor practicable to treat the leather manufacture in a cyclopædic form in this place; but the circumstances may usefully be pointed out which give rise to different branches of the art, and to the greater development of some of them than of others.

Skin or membrane becomes leather by various chemical processes; and the more complete these processes are, the more thoroughly does the substance lose its organic putrefactive liability, and become tough, strong, and flexible, wonderfully durable, and applicable to a great variety of purposes. Hides and skins differ greatly in thickness; they require different agents to bring about the change in their condition; there is thus a twofold reason why the leather should be widely diverse in its practical applications. First, then, a few words concerning the kinds of hides and skins operated upon.

Bull hide is used for the soles of boots and shoes, for many parts of saddles and harness, for leather trunks, buckets, fire hose, and pump valves, for soldiers' belts and cavalry gloves. *Cow* hide is similar in character to bull, but thinner, weaker, and finer. *Bullock* hide is intermediate in quality between bull and cow. The American *bison* or *buffalo* has a hide which produces tougher leather than most European cattle. The *urus* hide, obtained from the wild bull of Hungary and Southern Russia, is converted into very tough *buff* leather, almost pistol-proof and sword-proof. The *hippopotamus* and *rhinoceros* hides

are converted into leather of enormous thickness; but the process is slow and difficult, and the product costly. *Calf* skin (not usually called hide) is largely used for the upper leathers of boots and shoes, and in bookbinding; if the cow is killed before the infant calf is born, the thin skin of the latter is converted into the exquisitely fine leather used for Limerick gloves. *Sheep* skin, according to its thickness, produces leather varying much in quality; in one form it is used for cheap bookbinding and for leathering bellows; in another it yields white leather for aprons and whip lashes; while in another it is converted into wash-leather, for gloves, under waistcoats, and other articles. Sheep skin is also used for imitation morocco, and for a large variety of dyed and coloured leathers. *Lamb* skin is mostly used up for glove leather, white or coloured. *Goat* skin is the material for the best morocco, and for several other superior kinds of leather. *Kid* skin is the best of all materials for the leather of ladies' gloves and shoes; much of that sold, however, under this name, is a thin variety of cheaper leather, dressed in imitation of kid. *Deer* skin, when dressed in a particular way, produces the leather for riding breeches. It was not a mere freak of fashion that brought about the change from leather breeches to cloth trousers in the clothing of our cavalry; army surgeons found that the leather became unhealthy to the wearer in wet weather. Among other purposes, deer skin is now extensively used for gloves. *Antelope* skin, small in quantity, is used for some such purposes as deer. *Horse* hide, thin in comparison with its extent of surface, is much in request for collars and other parts of harness; also for the upper leather of shoes. *Pig* skin produces the best of all leathers for saddles. *Hog* skin is useful for some kinds of shoe and glove leather. *Seal* skin is dressed into leather bearing some resemblance to that of the dog. *Rat* skin occupies a place among the kinds converted into leather used for gloves and thin shoes. *Monkey* skin, *porpoise* skin, and numerous other varieties are tanned or dressed into leather, but only in small quantity.

Next we may notice the chief drugs which convert the skins and hides into leather. At the head of the list stands *oak bark*, stripped chiefly from young coppice trees. It may be said, as a general rule, that the bark, roots, and leaves of a considerable number of plants yield a yellowish-brown astringent solution, when soaked in water; that this solution contains a principle called *tannin*, which corrugates and constringes living skin, and converts dead skin into leather; and that so long as the tannin can be obtained in sufficient quantity and at a reasonable price, the tanner is not solicitous from which plant it is obtained. *Sumach* or *shumac*, another tanning drug, consists of the leaves and young branches of the sumach plant. *Wild olive* leaves and young branches contain about as much tannin as sumach. *Mimosa*, a fluid extract from a kind of wattle-bark, is coming into use as a tan drug. *Valonia*, the acorn cup of a species of oak grown in the Levant, is rich in tannin; as are likewise *catechu*, *cutch*, and *terra japonica*, obtained from the bark, wood, and leaves of the acacia catechu. *Divi-divi*, the pod of a South American plant, is finding its way to Europe as a tan-drug. *Nut-galls*, excrescences found on the leaves and bud stalks of a species of oak, are rich in tannin. *Myrobalams*, the yellowish-brown fruit of an East Indian tree, contains a good deal of tannin in the husk. *Larch bark* is useful in preparing what is called *basil* leather. *Willow bark*, much employed in Denmark, tans skin into good glove-leather. *Cork*, or the bark of the cork tree, is ranked among tan drugs in the South of Europe, but not in England. It is not simply a matter of supply and price as to the kind of drug which the tanner employs; he is influenced in his choice by the tanning potentiality (so to speak) of each variety. Thus oak-bark continues in high favour for producing good leather of a pleasing light fawn colour; valonia produces leather of a greyish tint, heavy and solid, and exceptionally impervious to water; catechu or terra japonica, though in favour for producing leather of a rich dark fawn colour, has this disadvantage, that the leather is somewhat spongy and pervious to water.

It would be impossible to state with any degree of accuracy the quantities and values of the tanning materials used in this country, because those obtained from English plants are seldom estimated statistically; and because, of those obtained from abroad, much of the extract is used in making dyes, stains, pigments, and inks. The following are one year's imports of some of the substances named, as given in the Board of Trade statistical tables for 1873:—

Bark, tanners' and dyers',	466,113 cwts.	.	£176,800.
Cutch	6,991 tons	.	146,111.
Valonia	20,662 „	.	518,066.
Gambier	22,567 „	.	538,145.
Sumach	12,292 „	.	206,617.

Besides the tanning drugs, properly so called, there are substances used in the conversion of skins into thin leather by a kind of dressing rather than by tanning; in cases where the killing (so to speak) of the animal membrane does not depend on the formation of a chemical tannate. The sorts of skin and leather so treated we shall mention presently; it will suffice here to say that the chief substances now adverted to are alum, oil, and white of egg.

If it were an accusation brought by an outsider, the trade might fairly set it down to ignorance; but when the "Tanners' Journal," devoted wholly to this class of subjects, says that Bermondsey does not understand the drugs which it uses, there is reason to open one's eyes. "There is a great want of technical education among tanners. We believe we are speaking within the truth when we state that not more than five per cent. of our present tanners are able to test, even roughly, the value of the different tanning agents they employ; or are in a position to tell with certainty whether they have sufficiently extracted the tannic acid from the backward oozes." It is known in this as in other arts, that foreign manufacturers pay more attention to science than English. The Austrian government has recently established a school of instruction for the application of chemical science to the art of tanning; a director superintends the studies and experiments, and encourages the trial of new drugs and new processes. It will not do to say that the English government ought to adopt a like plan; the richest manufacturing nation in the world should not depend on government or legislature in such matters.

The Tanning of Thick Hides.

Some of the firms in Bermondsey direct attention to thick hides only, some to thin skins, a difference which depends greatly on the processes adopted. Tanning, in its completest and most extensive form, is the conversion of thick hides into leather for boot and shoe soles, harness, belts and straps, and other purposes in which strength is indispensable, without sacrificing suppleness. The resources of the tanner's art are more called for in this than in the dressing of thinner skins: not in the processes themselves, but in the laudable attempt to discover some mode of shortening the time consumed in the conversion of thick hide into thick leather.

One of the preliminaries is the removal of the hair which covers the outer surface of the hide. The hides of our own cattle are brought to the tanner in a fresh state; but those from abroad are either dried or salted, in order to shield them from putrefaction during the voyage. According as they are fresh, dried, or salted, so is the amount of steeping to which they are subjected, and so the composition of the alkaline or acid liquor which forms the steep. The foreign hides require much rubbing and beating in addition to the steeping; and all alike require the removal of such small portions of flesh or fat as may adhere to the cutis. Sometimes lime-water, sometimes the heat of a smoke chamber, is used to expedite the loosening of the hair; and foreign tanners have recently introduced the practice of employing charcoal, as well as that of steaming, or exposing the hides to the action of steam in a closed chamber. It is probable that no one process is better than all others, each being suitable for some one kind or condition of hide. When the hair is loosened on one surface, and the thin cutis or cuticle on the other, both are scraped off by *beaming;* the hide is stretched over a kind of wooden horse called a beam, and scraped with a curved knife. As we have already spoken of the necessarily dirty nature of the tanner's operations, we need not dilate on the sloppy discomforts of the beaming process; more pleasant is it to say that every scrap of hair and cuticle is applied to useful purposes by the ingenuity of Bermondsey.

Then comes the tanning, properly so called. The tan-yard is provided with numerous tanks or pits on a level with the ground, some round or oval, some square or oblong, as the case may be. Every tanner has his secrets, or at any rate, his favourite modes of procedure. Very weak sulphuric acid, sour rye water, sour barley water, and other liquids, are employed to *raise* the hide, that is, so to open the pores as to facilitate the action of the tan liquor; or else the pores are opened by the action of a fermenting heat. The tan liquor itself differs, according to the judgment of the tanner; but oak-bark ground to a powder in a mill is the chief component relied upon. Sometimes a pile of hides is interlaid with strata of bark powder, and then the pit filled up with water; at other times a strong solution is made at once, and the hides plunged into it. Some tanners use cold water, some prefer hot, some steam; while others do not want clean water at all, but fill the pit with *ooze*, or exhausted tan liquor, re-invigorated with more tan. Then again there are differences in the strength of the liquor, according to the theory which the tanner may hold as to the best mode of converting the hide into tannate of gelatine (which is approximately the chemical nature

of all leather). The hides are not allowed to remain untouched in the pit; they are turned over and routed about, in order that the ooze and tan, renewed from time to time, may act effectually on every part. 100 lbs. of thick ox-hide will produce 120 to 140 lbs. of leather, according to the mode of conducting the operations.

The last remark at once introduces us to the main question, the *experimentum crucis*, in tanning—how to quicken the operations without injuring the leather. Few persons except those connected with the trade know how seriously prolonged is the duration of these operations. When we learn that from four months to three years is consumed in the thorough tanning of a thick hide into thick leather (the exceptional seven or ten years for wild boar, rhinoceros, or hippopotamus hide may be left out of consideration), we see how large must be the amount of capital lying dead, and how heavily this must increase the selling price.

The specifications of patents show how eagerly inventive men are endeavouring to solve this problem; the novelties are very numerous, but we fear that the fees and stamps of the Patent Office have more than absorbed the advantages derived by the patentees. A very brief mention of some of the inventions is all that can be given here. Sometimes the hides are hung vertically in the pit; but this produces injurious folds or creases unless frequent shifting is adopted. Sometimes they are each sewn up into a sort of bag, which is inflated, filled with tan liquor, and then set floating in the tank; but this is only effective with light and thin hides. Spilsbury's plan forces the tan liquor into the pores by mechanical pressure—a method that unluckily over-tans the thinner parts, while the thicker are still half raw. Blake's plan seeks to tan from within outwards, by sewing two hides together into a bag, filling it with ooze, and making the ooze penetrate the substance partly by pressure and partly by heat. Cox's and Chaplin's patented methods partake of Blake's bag form, but, like it, they are marred by practical difficulties. Coghlan's plan consists in making each hide into a kind of hollow trough in the tank, piling many of these troughs one above another, filling with ooze, and placing layers of sawdust between them. Herapath's method is to treat the hides as one would a sponge when cleaning it; soaking them with weak ooze, squeezing it out, soaking with a stronger ooze, squeezing it out, and so on repeatedly, until the substance of the hide is of the proper tint of brown all through; the pressing is effected by rollers, weighted by levers according to the degree of pressure required. Clarkson's patent relates to the application of a solution of chloride of soda and ammonia before the tan liquor. Preller's plan is somewhat complicated. The hides, after washing, unhairing, and partially drying, are covered uniformly with a paste of some kind of meal or starch moistened with some kind of oil or grease; the hides, thus smeared on the flesh side, are rotated for some time in a drum, to which steam is admitted. They are taken out, dried, coated with paste again, and rotated again; these processes are repeated three or four times over. If this is all, the hides are dressed rather than tanned, for neither the meal nor the oil contains tannin. When applied to thin hides or thick skins, this operation is said to produce rapidly leather useful for many purposes, though not so tough and durable as regularly tanned leather. Squire's patent depends on the agitation of the hides in hot ooze, contained in a cylinder having ridges in the inside to turn the hides over and over; air is as much as possible excluded. Bordier's plan is to employ metallic or earthy solutions instead of vegetable; one variety consisting of copperas, black oxide of manganese, and sulphuric acid. Cox's system suspends the hides in a rotating drum or cylinder, so disposed as to roll up and unroll them repeatedly, and facilitate the entry of the ooze into the pores. Many inventors have tried, and many more view favourably, the plan of exhausting a tank or closed receiver by an air pump, and forcing tan liquor into the pores of the hide by a pressure-pump; the theory is that the tan can act more quickly when the air is removed out of the way.—We might lengthen this list considerably; but enough has been said to show how eagerly tanners are on the search for plans by which the tanning of thick hides may be expedited and cheapened.

When the conversion into leather has thus far proceeded, the hides are hung up in a shed, and allowed to dry slowly; but at intervals during the drying they are subjected to much beating, rubbing, or rolling, to impart firmness and density. A kind of yellow bloom appears on the surface of the leather, which is removed in after processes.

The Dressing of Skins and Thin Hides.

Although the tanning of thick hides is, for the reasons we have stated, the most important branch of the art, it is not the most interesting in its technical details, nor does the leather produced find its way into such diverse uses as those kinds which have their origin in skins and thin hides. Let us glance rapidly at some of them.

Sumached or morocco leather.—The upper leather of men's boots and shoes, whether made of calf, cow, or dog-skin, is mostly tanned by a quick process, after the skin has been pared or shaved on the flesh side to a proper degree of thinness; and then requires much currying (of which presently) to give it the requisite smoothness and flexibility. Goat-skins, especially for the beautiful material called morocco leather, are tanned with a solution of sumach. When unhaired, limed, and washed with alkaline liquor, each goat-skin is sewn up into a bag with the grain or hair side outwards; this bag, or bladder, is nearly filled with strong sumach solution, then filled up with air by blowing into an orifice at one end; the aperture is tied up, and the bag thrown into a large tub of sumach liquor, where it swims about in companionship with many similar bags. By this soaking, with a little routing about and pressing, the skins are tanned in a few hours. After opening, washing, rubbing, and drying, the skins are dyed, and then receive that peculiar crinkled appearance of surface which is peculiar to morocco leather; this is produced by rubbing with a grooved piece of glass, stone, or hard wood. The ingenuity of the leather-dresser has been successfully exerted in producing "imitation morocco" in sheep-skin. Morocco leather, both real and imitation, is, as most persons are aware, largely used for coach-linings, chair-coverings, bookbinding, &c. The sumach plan is adopted for *roan* leather, sheep-skin prepared for slippers, cheap bookbinding, &c.; and for *skiver*, thin, poor sheep-leather for hat-linings, pocket-books, work-boxes, and sundries.

Tawed or Alumed Leather.—An enormous amount of soft thin leather is made of kid, sheep, and lamb skins by the operation known technically as *tawing*, in which alum is employed. After various preparatory processes the skins are plunged into a solution of alum and salt, to which flour and yoke of egg are added for the finer kinds. The thick solution (a sort of emulsion) is forced into the pores by rubbing with the hands, by treading with the naked feet, or by rotating in a barrel. Much stretching, rubbing, and smoothing are requisite to give finish to the leather thus produced. Gloves are made in vast quantities of this leather, white or dyed, especially by the French; the best are kid, the others are sheep, lamb, and other cheap kinds of skin. Sheep skins are sometimes tawed with the wool on, for housings, &c.; in which case the wool side is carefully folded inwards, to protect it from the alum emulsion. Eggs are consumed in vast number in the factories where real kid leather is made; they are preserved fresh for a long period of time in lime-water.

Shamoy or Oiled Leather.—Chamois is the proper name for this article, which, in its best form, is made from the skin of the Chamois goat; but the name has transformed itself into *chamoy* or *shamoy*, and the skin employed is much more frequently that of the sheep than of the goat. By a beautiful machine—one of the few really scientific machines used in the leather manufacture—almost any kind of skin can be split into two thicknesses, one having the flesh side and the other the grain side; and as these two kinds are applicable to different purposes, the splitting machine is now largely brought into requisition. Nay, this is not all. Skilled workmen can actually split a sheepskin into *three* thicknesses, of which one is dressed into leather, another converted into parchment, and the third (thinnest and most irregular) consigned to the glue manufacturer. Shamoy leather or wash leather varies much in quality, but it always is, or ought to be, very soft and pliable. The processes are numerous, but simple. The skins are rubbed with pumice stone on the grain surface, steeped in lime-water, washed in sour bran to open the pores, wrung or pressed till dry. Then comes the oiling. Several skins are well saturated with cod oil (not the expensive cod-liver oil), put into a kind of trough, and well beaten with fulling stocks; the skins roll over and over as they are beaten, and the oil is driven into every pore. Eight or ten times over is this beating or fulling repeated, with an interval of drying after each; until, for the best leather, two or three gallons of oil have been absorbed by a hundred skins. The leather is allowed to ferment a little in close chambers; after which it is washed in a weak alkaline solution, and dried. Some of the best buck and doe leather is used for riding breeches and riding gloves; the varieties made from sheep skin are applied to numerous inferior purposes.

Curried Leather.—In strictness there is no one particular kind of leather called by this name; but many varieties undergo the process of currying, and hence the designation. Let a hide or skin be tanned in what manner it may, the leather is unfit for practical use until rendered soft, smooth, flexible, supple; and this finishing is sometimes called currying, sometimes dressing. In currying, a tanned hide is moistened with water, beaten with a wooden mallet on a strong hurdle, scraped and pared on the flesh side by means of a two-handled knife, and rubbed on the grain side with pumice stone. Then, to give pliancy and a

granular appearance to the leather, it is rubbed over and over again with a pommel, a block of hard wood having surfaces marked with parallel grooves, or with a block of cork free from grooves; by folding and unfolding, this rubbing with the pommel is applied both to the grain and the flesh side. Knives of singular shape are then employed to get rid of any slight irregularities of thickness. Sometimes polishers of smooth wood or glass are used. The combined effect of all these scrapings and rubbings is to give to leather those qualities which render it unlike all other substances whatever. The tanner and the leather worker have still some reason to insist on the old adage—"nothing like leather." Many processes of dressing or finishing do not come under the name of currying. If the leather is to be dyed this is done after some and before other of the dressing processes. For some purposes leather is dressed "black on the grain," that is, blacked or dyed on the grain side instead of the flesh side; this requires a special kind of currying or dressing.

Russia and Shagreen Leather.—Just a few words concerning two peculiar kinds of leather. In making Russia leather the skins are steeped in an alkaline liquor, beaten or fulled, fermented, unhaired, and washed clean; then tanned by several steepings in a hot decoction of willow bark, each stronger than the preceding; then dyed. The special characteristic of this kind of leather is produced by dyeing with an infusion or decoction of the aromatic sanders-wood, which, taken in conjunction with the other processes, keeps the leather free from mouldiness in damp situations, repels insects by its odour, and thus renders priceless service in the binding of valuable books. The currying with the empyreumatic oil of birch bark is so managed as to give a peculiar granular appearance to the surface. *Shagreen* leather, used for covering small cases of various kinds, is made of skins which are salted, dyed, and finished with oil rather than tanned. The projecting granules of the surface are produced in a singular way; small round hard seeds are strewn over the grain side, covered with felt, and trodden in; when dry they may be shaken out, and protuberances are left on the flesh side, which are preserved during the subsequent operations.

Japanned, Enamelled, and Embossed Leather.—Great ingenuity is displayed in giving an exceptionally beautiful appearance to leather employed for decorative purposes. Much of the leather used in coach and harness making receives a coating of elastic japan varnish; and this japanned leather, when further treated, becomes as smooth as glass and quite impervious to water. *Enamelled* leather is still more perfect. The leather receives several coatings of a paste made of boiled linseed oil and black pigment, being dried at a temperature of 160° Fah. after each coating. The great usefulness of this leather lies in these qualities—that it may be folded without creasing or cracking; and that when used for dress boots or for ladies' boots and shoes, it may be cleaned by sponging without blacking. *Embossed* leather, usually sumached sheep skin, acquires a decorative *rilievo* surface by the action of heated engraved rollers. Sometimes leather is *corrugated* by passing between heated grooved or fluted rollers. Another kind of rilievo is produced by pressing the moistened leather into moulds.

Leather at the International Exhibition.

In the natural course of technological sequence, as announced by the Commissioners of the Annual International Exhibitions, leather had its place; and 1874 is the year when the exhibits in this branch of industry display themselves. The present occasion is not a fitting one to dwell on the doleful rumours concerning the collapse of the whole enterprise; of the loss of many thousands of pounds last year; of the probability of a still heavier loss in the present year; and of a resolution to wind up the undertaking in 1874, instead of continuing it till 1880. Who is to blame? is an easy question to put; the time for a definite answer will be when the authoritative announcement is made public of the abandonment of the work. Meanwhile, it may be well to call to mind the real scope of the series, to see how far it has gone to the present time, and what was intended to be done in the last six years of the period. Every year was to have its exhibits in fine arts; giving that term so wide a meaning as to include sculpture, architectural ornament, oil and water-colour paintings, pencil and crayon drawings, engravings, etchings, photographs, plain and chromo-lithographs, autotype and heliotype reproductions, carvings, artistic castings, bronzes, enamels, mosaics, &c. Every year, too, was to comprise illustrations of new scientific discoveries and mechanical inventions. But beyond these limits, each year was to illustrate some few branches of industry, taken in such order that a sort of curriculum of technology would be filled up. Beginning in 1871, and continued uninterruptedly till 1880, the following was to have been the programme:—1871—Pottery and porcelain; woollens and worsteds; educational works and appliances. 1872—Cotton and cotton goods; jewellery, and the smaller works in gold and silver; music and musical instruments; paper, envelopes, and stationery; printing, type founding, and type-composing and distributing machines. 1873—Silk and velvet; steel and cutlery; carriages and velocipedes; substances used as food; cooking, its science and its appliances. 1874—Cushion and machine lace; civil engineering and building contrivances; leather and saddlery; bookbinding; wine. So much for the past and the present. We may here remark, as a curious feature in the management for the present year, that sixpence extra is demanded for admission to one particular part of the Exhibition, viz. the department of wines; no public explanation has been given of the reason for this exception to a general rule. Let us briefly notice the remaining six years of the (once intended) series, so far as the programme of the Commissioners furnishes the means. 1875—Printed and dyed tissues and yarns; clocks, watches, and other time-measurers; brass and copper manufactures; pumps, hydraulic machines, and water supply apparatus. 1876—Gold and silver work, real and imitation; photography; skins, furs, feathers, and hair, and their manufactures; philosophical instruments; electrical appliances; agricultural implements. 1877—Furniture and upholstery; paper-hangings and house decorations; sanitary manufactures. 1878—Tapestry, embroidery, and needlework; stained glass, window glass, table glass; military and naval engineering; stoves and heating apparatus. 1879—Straw and other plaiting, matting, and netting; flax and hemp, materials and manufactures; tin, lead, zinc, and pewter manufactures; dressing and travelling cases; horticultural appliances; useful applications of magnetism. And lastly, 1880—Chemical and pharmaceutical substances; made-up clothing; locomotive engines; railway plant.

Reverting now to the subject of leather, as taking part in the exhibits of the present year, it appears to be admitted in the trade generally that the display is somewhat of a failure. The "Tanner's Journal," already adverted to, says that Bermondsey has put forth very little of its strength, the most eminent firms not having vouchsafed to exhibit at all; while many foreign countries, known to be producers of excellent leather, are conspicuous by their absence. "A carping critic might complain that the leather exhibits are somewhat put in the background by elaborately harnessed dummy horses, caparisoned with equal completeness either for the battle or the chase; but the dummy horses carry leather on their backs, and are only exponents in another form of—leather." Whether, as some say, Bermondsey tanners are a little jealous one of another, and are afraid of revealing trade secrets; or whether, as seems more probable, they are indifferent to the Exhibition, must be left to themselves to decide. The Royal Commissioners, it appears, sent to the "Tanner's Journal" to state their hope and desire that the materials, such as the drugs and the tools, employed in tanning and leather dressing would be well represented. This hope has been sadly frustrated; only one case or glass enclosure contains specimens of tanning drugs. Another trade journal, "St. Crispin," devoted more especially to the boot and shoe industry, but taking note of all that concerns leather, administers a somewhat severe rap to the authorities. "It will be necessary for the Exhibition Commissioners to take measures to ensure a passable collection of manufactures in coming years; or there will be greater lengths of dismal, empty corridors to suggest to the scientific man and the workman that there is something radically wrong in the capabilities of the committee of management." The Commissioners and the trade must share between them the following hit:—"Any one of our leading manufacturers could have made as good a display, without inconvenience to his business. Almost the same may be said of the harness and saddlery, so few are the exhibits."

If there is any failure, it certainly cannot be imputed to the absence of advisers. Besides the Royal Commissioners for the Great Exhibition of 1851, who are also the Commissioners for these Annual Exhibitions—besides this majestic list, comprising six royal princes, dukes and earls in plenty, nearly twenty cabinet ministers (past and present), and a strong muster of scientific men, and besides a Board of Management—there is a Committee of Selection for leather, saddlery, and harness, headed by three peers of the realm, and comprising thirty-six other gentlemen, who, although their names are not in general familiar to the public, may be supposed to know something about leather. Are we to assume that too many cooks spoiled the broth; or that the cooks did nothing, and allowed the broth to make itself?

A visitor is somewhat embarrassed in his peregrinations, because the exhibits of leather are not separated from those of leather manufactures; and because all countries (all which are among the exhibitors) are jumbled together without much order. Picking his way, however, and using his eyes, he finds that

Messrs. Wilson and Walker have sent from Leeds a large and well assorted case of specimens, comprising numerous varieties of coloured leather; that Messrs. Evans of Bristol have succeeded in tanning hippopotamus hide fully one inch in thickness; that Messrs. Harrington offer to the public imitative leather for bookbinding, resembling real leather sufficiently to deceive many an outsider; that leather-cloth shows itself somewhat garishly, rather too smart with varnish and polish; that Stowmarket sends driving bands for machinery, so long, broad, and thick, so well sewn and riveted, as to be worth £20 or £30 each; that a South American ox-hide comes forth as a substantial piece of leather little less than half an inch in thickness, welcome for the soles of men's winter boots. The tan-drugs, already adverted to as being almost lonely in their loneliness, comprise sumach, cutch, gambier, hemlock, oak bark, valonia, dragomestra, camatina, mimosa bark, tenekaha bark (from New Zealand), cork bark, larch bark, divi-divi, rabool, and myrobalams. Messrs. Hooper deserve credit for exhibiting that which others have neglected.

The articles manufactured in leather are much more numerous and varied than the specimens of leather itself. Trunks and portmanteaus are in great force, and vie one with another in the ingenuity with which a whole wardrobe of apparel may be packed in a small space. The trunks for accommodating ladies' dresses and millinery for the seaside, when paterfamilias consents to a family tour, are nearly as large as the mysterious cabinets of our conjurors; and we are bound to suppose that they are well arranged for the purpose intended. Bags and cases, for other purposes, are as diverse as tastes and purses can desire. Leather buttons are plentiful, and look as if they would last for ever. Leather ornaments, produced by stamping and pressing, for looking-glasses, picture frames, and small articles of fancy furniture, are in some instances pretty and graceful, the rich brown of the leather enhancing the effect. The saddlery and harness trades are fairly represented; although it might be wished that the strong rougher work for waggon and cart harness had received some of the attention which has been rather too exclusively bestowed upon the saddle-horse and the private carriage. Among the few curiosities in this department are the horse trappings once belonging to the Duke of Monmouth; those used by the Duke of Buccleuch at the coronation of her present Majesty; the saddle presented to the Queen by the Emperor of Morocco; and the saddle-cloth presented by the same potentate to the late Prince Consort.

The foreign leather-workers make a fair display, considering how few foreign countries have entered into the matter at all, and how oddly the contributions are mixed up in this ill-arranged building. The display of russia leather from Russia is noteworthy, on account of the rich deep warmth of the red-brown tint. It is no small credit to the manufacturers of that country that they have introduced a kind of leather which comes more and more into favour the more extensively it is known. Austria sends good strong leather for coarse purposes, as well as the more highly finished kinds; while in articles of leather manufacture the Austrian empire yields to no country in Europe for skilled workmanship and delicacy of taste. Let not the visitor be frightened at the scarcely-pronounceable names of some of the exhibitors—Schmalzl of Vienna, Szklarski of Cracow, Lachnik of Olmütz, Zaehnsdorf, and the like; the things are worth looking at, despite the names. The collection from Japan is perhaps the most interesting of all, so varied and ingenious are the modes in which that singular people prepare their leather. Some kinds are gorgeously gilt, others covered with a kind of small mosaic pattern; others perforated through and through almost as completely as lace. There is also from Japan an oil-soaked wall-paper, presenting an appearance somewhat midway between leather and oil-skin or thin floor-cloth, tough and serviceable.

It would have been well if the machines and tools employed in the leather trade had been more fully exhibited. Some of the sewing machines are such as are used in saddle and harness making. Messrs. Stoddart and Pitt exhibit butt rollers, belly-hide strikers, and leather rolling machines; Messrs. Perreux, pumps and pumping machines for tanneries; Messrs. Toleman, rollers for producing grain or granulated leather; and Mr. Wilson, an improved mill for grinding oak and other tanning barks. Mr. Turner, of Nottingham, sends an ingenious machine for scudding, puring, and scouring split and unsplit hides and skins; the skins are placed on a front roller, drawn in by revolving machinery, and exposed to the action of two spiral brushes which work against each other at right angles; this brushing, aided by hot water, stretches the skins, cleanses them from grease and filth, brings the grain into a soft state, and prepares it for the reception of dye. The puring, puering or pewering above mentioned means a cleansing by means of a liquid called pure, concerning which we are told, by advertisements in the trade newspaper, that "a regular supply of good kennel pure can always be had."

It may be right to observe that *boots* and *shoes*, perhaps the most important of all the applications of leather, are not shown in the present exhibition. It was the announced intention of the commissioners to include them among made-up clothing, in some future year of the series; whether this plan is now abandoned, the future must show. We may also remark that although *bookbinding* is included in this year's exhibits, it is not regarded as belonging to the leather trade, although much leather is used in whole-bound and half-bound volumes. The best leather exhibition, *per se*, we have ever had, was perhaps that which was held in 1873 at Northampton, the head-quarters, or one of the chief head-quarters, of the boot and shoe manufacture. Everything, from first to last, was well shown there, from the raw hides and skins to the finished articles in leather; through all the intermediate stages of tanning, tawing, currying, dyeing, dressing, polishing, enamelling, embossing, cutting out, sewing, pegging, riveting, &c.; with the machines, tools, implements, drugs, and materials.

Statistics of the Leather Trade.

No excise duty being imposed on home manufactured leather, there are no means of estimating the total annual value of this branch of our national industry. Numerous round sums, *very* round sums, have indeed been named; but as they conflict one with another, and as the bases on which they individually rest are not clearly stated, little reliance can be placed on them. We cannot tell how many British and Irish hides and skins are tanned in the United Kingdom; but we have the means of knowing how many foreign hides and skins are imported; or, if not the number, the weight and value. The figures for 1873 stand thus :—

Dry hides . .	615,548 cwts.	£2,433,038
Wet hides . .	712,040 cwts.	£2,292,289
Dressed hides . .	31,178,135 lbs.	£1,947,567

We find here an aggregate of nearly seven millions sterling in the value of the foreign hides, skins, and leather imported. The dry hides comprised 362,787 cwts. from British India, and 252,761 cwts. from other countries. The wet hides comprised 417,651 cwts. from Brazil and the River Plate regions, 30,803 cwts. from Australia, and 263,586 cwts. from other countries. The dressed hides comprised all the hides and skins which had to any extent been converted into leather by tanning, tawing, dressing, or currying. We do not work up all the foreign hides and skins we import; in the year just named we exported to other countries, without any manufacturing manipulations, to the quantity of 301,637 cwts. of dry (value £1,211,194), and 280,027 cwts. of wet (value £280,827). For the reasons above stated, any estimate of the value of leather-manufactures kept and consumed at home must be untrustworthy; but we know pretty nearly how much we sell to our neighbours. The figures stand thus for 1873 :—

Leather, unwrought . .	117,586 cwts.	£952,237
Boots and shoes . .	526,460 doz. pairs,	1,704,145
Saddlery and harness .	" "	455,112
Other wrought leather .	1,662,053 lb.	305,209

Three-fourths of the boots and shoes here adverted to were exported to our own colonies in Australia. From all the figures taken together, we learn that we send more money abroad to pay for hides, skins, and leather imported, than we receive from abroad for the hides, skins, and leathers we export.

If, as Mr. Freeman thinks, the grandfather (on the mother's side) of William the Conqueror was a tanner, the leather trade may feel a little proud; at any rate, leather working has always ranked among our staple industries.

New Danger Signal.—MM. Lartique and Laforest have recently invented a novel device, intended as a danger signal, which the "Revue Industrielle" states is now in successful use on some of the French railroads. A whistle is arranged on the locomotive so that it will, when once opened, continue sounding until shut by the engineer. The same device which turns the disc signal, so as to show the danger side, is intended to transmit a current of electricity to a little projection between the rails. When the engine passes over this spot, a metallic brush hanging between its wheels strikes on the projection and sweeps over it, at the same time transmitting the current to an electro-magnet which pulls the whistle open. The latter, by continuously sounding, warns the engineer.

THE "CITY OF PEKING."

WE extract from an American authority the following account of the steamship "City of Peking," built in the United States:—This latest addition to the Pacific Mail fleet of thirty-five steamers had not, up to the date of launching, been measured for register, but her gross burthen will fall very little short of 6,000 tons. Her extreme length of hull is 423 ft., by 47 ft. 3 in. breadth of beam, and she is 36 ft. deep between the top of the keel and the spar deck. She has four decks, and six water-tight compartments. She has accommodation for 150 cabin passengers, and 1,500 steerage passengers, and her coal bunkers will carry 1,500 tons. The bulkheads are fitted between double frames, so as to insure the greatest tightness and resistive power in the event of it ever becoming necessary to depend on them for safety. All the deck beams are placed on every alternate frame, with "knee" plates forged on them, and are riveted to the frames and stringers. Calculation has been made and jointings and sockets prepared for beams to support the engines and boilers in too many ways to admit of detailed description. The "shell plating" of the vessel varies in thickness. No plate is less than 12 ft. long, and each plate tapers to suit the ship's sheer. Every shell plate has been tested before being put into the ship, to several times the strain, in both simple and compound relations, it can ever be called upon to bear in actual use. All shell plates are flush jointed on the vertical section, and lap jointed on the longitudinal section; they are all riveted according to the rules of the Bureau Veritas.

All the ship's skylights are arranged to combine the maximum of utility, strength and water-tightness. The rudder is of the best hammered scrap iron, and every means that intelligence has devised and experience confirmed as useful has been employed to render this important part of the vessel absolutely secure.

The "City of Pekin" is furnished with the most approved steam steering apparatus, as well as with two other hand-wheel steering apparatuses, one forward and the other aft. The steam apparatus is furnished with a friction-brake to hold or stop the rudder at any point, and with a pointer to indicate exactly at what degree the rudder is at any moment.

The engines of the "City of Pekin" are correlative with the magnitude of the vessel. They represent 5,000 horse-power, and constitute, with one exception, the largest piece of mercantile marine machinery ever constructed. They consist of two pairs of compound engines. The stroke is 54 in. There are two low-pressure cylinders of 88 in. each, and two high-pressure of 51 in. each, thus giving an aggregate cylinder diameter of 278 in. Either engine may be detached from the other, and in case of breakage of one of them at sea, the sound one may be worked while the other is in process of repair, and will propel the vessel at two-thirds of its regular speed. The pumps for circulating the water through the surface condensers are independent of the main engines, which is a decided improvement.

This colossal machinery is to be furnished with steam from ten cylindrical boilers 13 ft. in diameter, by 10 ft. 6 in. long, the shell of each boiler being 13-16 of an inch thick, and double riveted. Each boiler has three cylindrical furnaces, with 204 tubes 3¼ in. outside diameter, by 7 ft. 6 in. long. The total grate surface in these ten boilers is 520 square feet, and the total heating surface is 17,000 square feet. This is the largest heating surface ever provided for the engine of any mercantile compound marine engines, and will evolve valuable economic results in permitting slow combustion of fuel, while the machinery is at full working power, and thus insuring a development not very often attained, namely, the complete consumption of all the coal put into the furnaces.

The propeller is a Hirsch screw, 20 ft. 3 in. in diameter, with four blades, and a mean pitch of 30 ft. In case of leak, the ship's pumps are capable of throwing 10,000 gallons (250 barrels) of water per minute. There are four donkey-engines, with separate boilers, which may be worked in connection with or detached from the main boilers. There are three freight hatchways on deck, each furnished with a steam winch, for hoisting and lowering freight. The forward winch also works the anchor, and the sails are hoisted, set, and furled by means of these winches, thus reducing the labour of the crew to a minimum.

Nothing has been left undone to render the "City of Peking" in every possible respect an absolutely perfect vessel. She enters the water as the pride of the American navy, and, without detracting from the worth of any foreign vessel, has no equal now afloat available for commercial purposes. She is one-fourth larger than the "Celtic," the largest White Star ship. Three years ago the almost universal belief was that no such vessel could be built except on the Clyde.

IMPROVED ICE AND REFRIGERATING MACHINE.

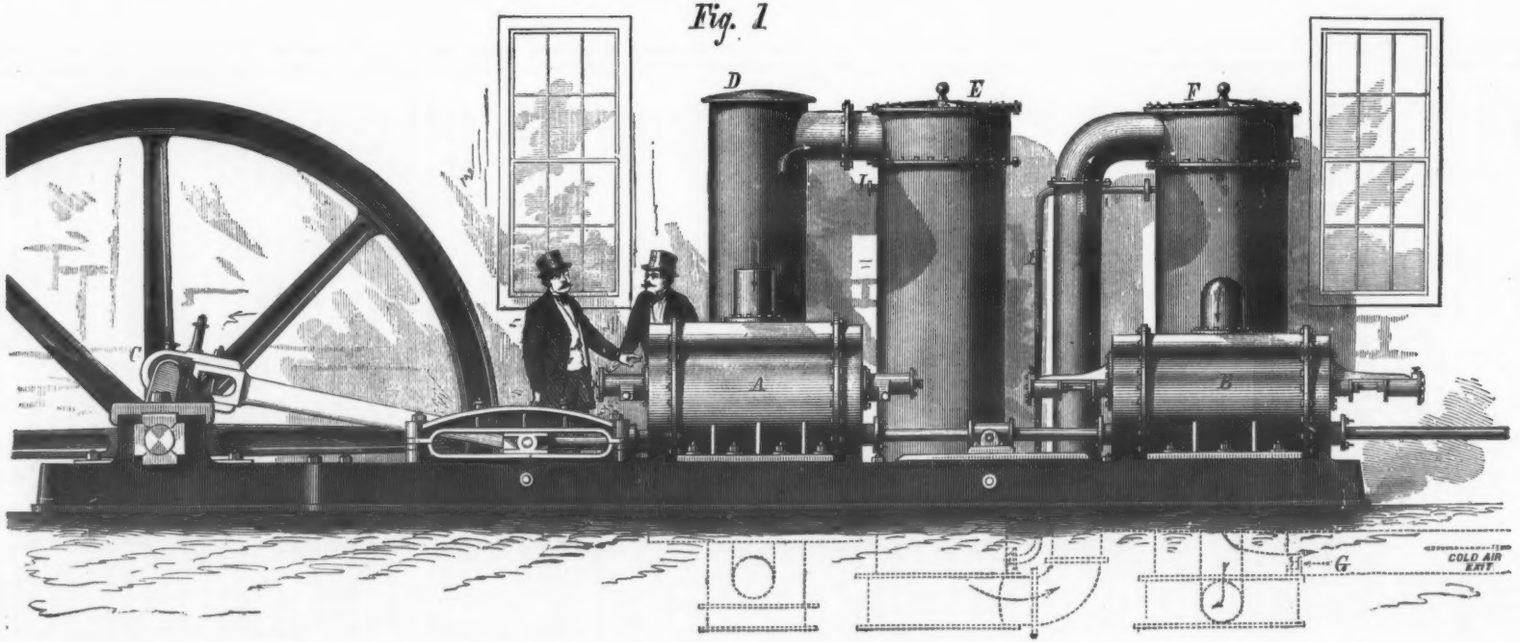
THE following is quoted from the "Scientific American":—The various inventions, which during late years have been devised for purposes of refrigeration, or for the manufacture of ice, may be divided into three principal classes—(1.) Those in which evaporation is effected in a vacuum, the process being assisted by the use of an air-pump, as in the other machines of Messrs. Siebe, Tellier, and others. (2.) Those in which air is first compressed and afterwards expanded, or, more generally speaking, those in which heat is applied in order to ultimately produce cold, exemplified in the apparatus of Kirk of Glasgow, Mignot of Paris, and the Windhausen invention, to which the following description will more particularly refer. (3.) Those in which cold is produced by the direct action of heat without the use of power, as in the case of refrigeration by the liquefaction and subsequent vaporization of ammonia, to which class belong the systems of Carré, Reece, Mort, and others of more recent date. In addition to the machines coming under the above heads may be noted others employing freezing powders and different hydro-carbons, numbers of which, possessing various degrees of merit, exist both in this country and abroad.

The Windhausen apparatus, which our engravings illustrate, was first patented in Germany; and may be fairly considered as among the most successful machines of its class yet produced. The principle upon which it is based is one of the simplest in physics, namely, that the compression of the atmosphere generates heat, and its subsequent expansion cold; an axiom too generally understood to need explanation here. The particular mode of its application in the present instance is, however, an important point; and, indeed, the entire efficiency of the device is claimed to rest upon the circumstance, that instead of cooling the air heated by compression by means of running water, and then conducting it directly to the space or apartment to be refrigerated, it is led into a chamber where dilation takes place. In short, expansion is effected by the simultaneous action of the machine before the air is sought to be utilized.

Our engravings represent an elevation, fig. 1, and plan view, fig. 2. A is the compression cylinder, and B the expansion cylinder, both of which are worked simultaneously by power applied to the crank, C, by the low pressure engine shown in the lower portion of fig 2. Air enters in the direction of the arrow into the upper part of cylinder A, which is of such dimensions that, at every move of the piston, nearly 35 cubic feet of air, or, as the former is double acting, twice that number, are compressed with every revolution of the engine. Thirty-six revolutions per minute, for example, compress 150,000 cubic ft. per hour, and at a pressure, it is stated, of only 35 lbs. per square inch, that is, reducing two and a-half volumes of air to one volume. Supposing the air on entrance to be at 80° Fahrenheit, it is stated that, after compression, experiment proves its temperature to be 205°, indicating a gain, therefore, of 125°. Leaving the cylinder, A, the current enters the condenser, D, from which, in the direction of the arrow, it passes to a similar receptacle, E, thence down, as indicated by dotted lines in fig. 1, to another cooler, F. Within these chambers are arranged series of pipes through which the blast passes, and which are surrounded by a current of cold water which enters at G (dotted lines, fig. 1), passes up through the cooler, F, through pipe, H, through the next cooler, and emerges at I. The effect of this water is to abstract a portion of the heat imparted by compression, reducing the temperature of the air to a few degrees above that of its natural state, the extent of this reduction depending upon the temperature of the water, and the length of time the air is submitted to its action. An atmosphere is thus obtained which, although under two and a-half compressions, is but slightly warmer than the ordinary air previous to treatment, while the expansive force and effect of a volume two and a-half times larger is retained. Consequently, it is claimed that the 125° of temperature above noted are clearly gained.

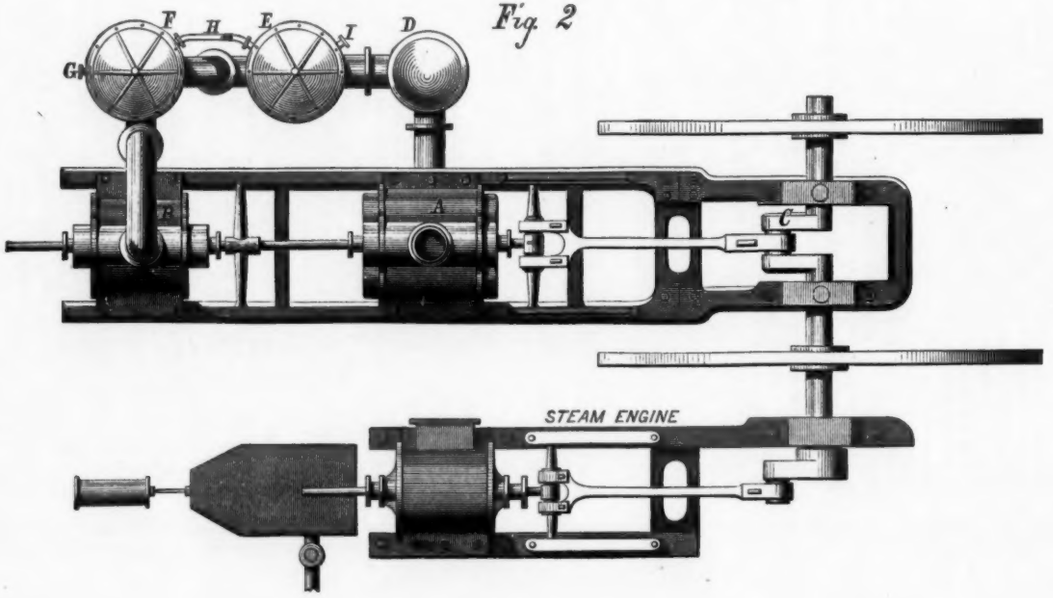
In this condition the air enters cylinder B, where the expansion takes place under a gradually diminishing pressure, regulated by automatic valves worked by the simple expansive force of the compressed air itself. To dilate the matter to its normal volume, it is evident that the same amount of heat is required as was abstracted by the water; but this can only be partially returned by the small quantity of air within the expansion

Fig. 1



THE WINDHAUSEN ICE AND REFRIGERATING MACHINE.

Fig. 2



cylinder, so that a low degree of temperature is at once obtained. This is still further reduced with every movement of the machine, as the original air in the expansion cylinder becomes colder, or rather replaced by the cooled and compressed atmosphere. As the compression and expansion cylinders are simultaneously double acting, the latter receives its supply only from the former, so that the compressed air is expanded by one and the same process; hence, if 150,000 cubic feet are compressed in one hour, necessarily the same amount must be expanded in a similar time.

From the cylinder B, the air escapes into the space to be refrigerated with great velocity, sufficient, it is stated, to be capable of conducting the current through channels 2 ft. in diameter, a distance of 300 ft. from the exit aperture, the measured temperature of the air at the orifice being from 30° to 35° below zero Fahr. It is also asserted that under a pressure of 35 lbs. to the square inch, at thirty-three or thirty-four revolutions per minute, the machine has, with an inadequate supply of water, since its erection at New Orleans, produced a temperature of 54° below the Fahrenheit freezing point. The apparatus, it is claimed, will sustain a pressure of 85 lbs. per square inch, or nearly six atmospheres, producing a most intense cold, scarcely susceptible of thermometrical measurement. Perfectly dry cold air is said to be found, the contained moisture being condensed into snow and appearing at the exit orifice.

This machine received the first prize at the Vienna Exposition. The apparatus now operating in New Orleans was built by Eygels, of Berlin, and was the first constructed on a large scale in Germany. The driving engine is 31 × 36, and works at from 50 to 55 lbs. pressure.

PROFESSOR THURSTON ON THE MOLECULAR

CHANGES PRODUCED IN IRON BY VARIATIONS OF TEMPERATURE.

THE above is the title of a reprint from the "Journal of the Franklin Institute" which, but for the pressure of other matters, we should have noticed in our earlier issues, but as it treats of a subject, the interest of which is a permanent one, there is perhaps but little ultimate loss to our readers by any delay which has occurred. We have seldom, we may at once candidly state, met with a treatise which, in so few pages gives so excellent a résumé of the author's opinions, or so much reliable data from other writers on cognate subjects as reasons for those opinions, by which data its readers have placed before them ample means of judging for themselves of the truth of the conclusions at which the learned professor arrives.

The premises on which Dr. Thurston founds his arguments are the following, which we reprint verbatim.

1. "All matter consists of indefinitely small parts, having dimensions and forms which are unchangeable by finite power, and which are endued with the properties of impenetrability and inertia.

2. "These 'atoms' are separated by spaces which are absolutely very small, but which are immensely great in comparison with the atoms themselves.

3. "Several atoms, when united by chemical force, form a molecule, and aggregations of molecules, with intermolecular spaces, make up the masses of all matter.

4. "Forces, both of attraction and repulsion, exist between atoms and molecules. These forces vary, in intensity, with changes of distance between molecules. The resultant of these sets of forces is sometimes attractive and sometimes repulsive, changing at times, and under definite conditions, from the one direction to the other. There may thus be exhibited several alternations of attraction and repulsion within a very minute range.

5. "At sensible and measurable distances the attractive force varies inversely as the square of the distance between the centres of attraction, and is termed gravitation.

6. "Gases manifest repulsion only in a degree which, in 'permanent,' or perfect, gases, varies inversely as the volume of the mass.

"Liquids exhibit a perfect equilibrium of attractive and repulsive forces, but offer immense resistance to the disturbance of that equilibrium, by effort to reduce their volume appreciably, and less, although still considerable, resistance to its disturbance by increase of volume.

"Liquids, however, offer exceedingly slight, and sometimes immeasurably slight, resistance to change of relative position of their particles, which, therefore, move more or less freely among each other, according to the greater or less viscosity of the liquid. They thus offer little or no resistance to change of form.

"Solids are composed of aggregated molecules existing in the same condition of equilibrium as is seen in liquids, and offering similar resistance to change of volume, but they differ from liquids in exhibiting resistance to change of form, which resistance can usually only be overcome by actual destruction of cohesive force. This peculiar condition is the result of that form of force which has been termed 'polarity.'

7. "These three forms of matter are not distinctly separated from each other, but the same substance may pass, by gradual change, from one to another of the several classes, and may, in its ordinary state, exhibit such physical characteristics as to make it difficult to determine to which of two classes it is to be assigned.

In addition to the above it may be added:

8. "Solid bodies offer a resistance to change of form, which, within narrow limits, is proportioned to the magnitude of that distortion.

"Beyond these limits the force producing change of form soon separates the atoms completely, by overcoming gradually the inter-atomic forces, and rupture takes place."

We are willing to accept these data, and now proceed to analyse the deductions made from it by the learned professor, whose pamphlet seems fairly to have exhausted in references all the recognized authorities on the subject.

The first great point, if not indeed the only actual one, for consideration is: what is the effect in iron of intermolecular forces? for we take it that no one disputes the fact that these forces exist, and, of course, if existing they must act and re-act upon each other; but let us just for a moment consider what these molecules are stated to be (see paragraph 3 above). It will then be seen that according to this theory there are distinct component parts in every molecule, *i. e.* first, the "atoms" separated, *mechanically*, as we read it, from each other by spaces absolutely small, but great in comparison with the atoms themselves, and then several of these atoms being united by chemical force in a molecule. These molecules are clearly divided in their composition by the spaces which separate the atoms *inter se*, as well as by any distances intervening between the individual molecules themselves. There is sufficient explanation in the paragraph we have quoted from Professor Thurston's pamphlet of the forces of attraction and repulsion existing between atoms and molecules, and the laws which govern them, to entitle us to dispense with further consideration thereof, and to turn at once to the principal object we have in view in writing this paper, namely, the especial effect produced in *iron* by these changes. Passing over, therefore, the lengthy dissertation and numerous passages quoted from such writers as Baden Powell, Faraday, Tresca, Boscovitch, Andrews, &c., which more especially relate to the effect generally considered of that condition of matter, sometimes known as the critical state, when it is passing from the liquid to the gaseous form, or the reverse, we come to the statement, that in metals, all other things being equal, "lowering the temperature reduces the mobility of particles and increases the viscosity," and that hence the greater toughness of the material at the higher temperature, while in a solid state, would not only exhibit itself in a greater resilience, but would also modify the character of the fracture, when ruptured by external force, making it less "short and glass-like;" and in support of this he quotes Theogold, and against it Dr. John Percy, towards the last of which opinions our own proclivities certainly tend; and we may name that without exception every one of our personal friends in the profession and the practical men we have been able to consult have been entirely of our advice, viz. that a decrease of temperature within certain limits produces a decrease of tenacity.

We do not suppose for a moment that any of the readers of this journal will imagine that we mean to give utterance to the opinion that above a certain temperature—as in fact the fusing point is approached—there is not a falling-off of strength. Clearly not, for that point once reached, tenacity ceases to exist, but our contention is that within the ordinary ranges of atmospheric temperature iron is stronger as the scale ascends and weaker as it descends, this weakness or want of tenacity increasing in a very much greater ratio after the freezing point is passed. This, as Dr. Thurston points out, is not in accordance with the report of the Committee of the Franklin Institute on the experiments made between the years 1832 and 1837, where it was found that the greatest strength was obtained at 572° Fahr., but

singular to say, no trials were made at temperatures below 32° Fahr. Now Kirkaldy distinctly comes to the conclusion that "the breaking strain is reduced when the iron is frozen;" but points out that "with the strain gradually applied, the difference between a frozen and an unfrozen bolt is lessened as the iron is warmed by the drawing-out of the specimen." And Mr. Brockbank found the cohesion of cast-iron perceptibly decrease with decrease of temperature. At this point we may refer for a moment to a statement which has been made by Professor Thurston in his note on the resistance of materials read before the American Society of Civil Engineers, November 19th, 1873, "that iron and steel if strained beyond the limit of elasticity, and left under the action of the distorting force which has been found just capable of equilibrating their power of resistance, gain resisting power to a degree which has a limit in amount approximating closely, if not coinciding with, the ultimate resistance of the material, and which had a limit, as to time, in experiments hitherto made, of three or four days." This we incline to think, putting on one side the question of elasticity and confining ourselves to the mere point of strength, may be looked upon as rather evidence against than for the professor's theory, for as the action of the distorting force would be to produce some measure, however small, of heat, it results that the addition of caloric or the effects of heat energy, produce an increase of strength, at all events up to a certain temperature, which is a conclusion quite at variance with the statement that at the "absolute zero—461·2° Fahr." (as to the absolute zero we need not say there is great difference of opinion) "cohesion and consequently the strength of the material, have their maximum value."

Again, Dr. Thurston says "that the statement recently made, that the real effect of decrease of temperature—other things being equal—may be to increase tenacity, has been received with very general distrust;" and we are individually able to bear witness to the fact that, on a day of severe frost, when the workmen have been moving merchant bars—say bolts or square of about 1" section—from one part of the works to another, the bars, if allowed by accident to drop, would snap off short, whilst on a day of ordinary temperature no such a thing would take place. And these are instances which we have noticed not only once, but frequently, and not with different qualities of iron, where the presence of "phosphorus and of other substances producing 'cold shortness' exaggerates to a great degree the effects of low temperature in causing loss of toughness and resilience," but with iron of the same make, of the same component materials, and with an inclination rather to be "*red* short" than "cold short."

Dr. Thurston, in the very last paragraph of his pamphlet, protects himself somewhat against what we have advanced, by saying that "iron probably does not lose its power of sustaining 'dead' loads at low temperatures, but that it does lose, to a very serious extent, its power of sustaining shocks or resisting sharp blows." We cannot see that even this argument can be justly maintained in face of Dr. Joule's experiments, which give as the result of decreasing temperature in general increased strength, but decreased elongation and resilience. For, we would ask, in what does this increased strength consist? A frozen bar of iron will certainly not sustain a greater suspended weight than one at a higher temperature. Is, then, this strength to be construed as merely a greater power of resistance to a crushing or disintegrating force? And even this we do not think is the case; and, as we have said before, every one of the practical workmen we have had opportunities of consulting, are of our opinion.

We here for the present leave Professor Thurston and his theory, to which we shall probably have to refer again when considering the data furnished by some experiments made on the "Tensile Strength of Bar Iron and Boiler Plate, by Mr. L. B. Richards," a report of which has appeared in the "Transactions of the American Society of Civil Engineers."

THE STATISTICS OF PAPER-MAKING.—Some curious statistics relative to paper-making have been published by Rudel, of Vienna. It appears that there are 3,960 paper manufacturers in the world, employing 80,000 men and 180,000 women, besides 100,000 employed in the rag trade; 1,809 millions of pounds of paper are produced annually; one half is used in printing, a sixth for writing, and the remainder for packing and other purposes. The United States, with 3,000 machines, produces yearly 200,000 tons of paper, which, for a population of 28,000,000, averages 17 lb. per head; an Englishman consumes 11½ lb.; a German, 8 lb.; a Frenchman, 7 lb.; an Italian, 3½ lb.; a Spaniard, 1½ lb.; and a Russian only 1 lb. annually, on an average.

Special Correspondence.

PARIS, *June* 20.

Extinction of fires caused by petroleum: Experiments by M. P. Moigno.—Chavigné's carbonization kiln.

To the Editor of the PRACTICAL MAGAZINE.

I HAVE to report upon two new matters of recent occurrence in the industry of France, the interest of which will doubtless be appreciated by some of your readers.

The doctrine of the inflammability of chloroform has been generally accepted up to the present time. M. Würtz, in his great dictionary, states that a cotton wick dipped in chloroform will burn. M. Moigno has been making experiments which seem to point to a completely opposite doctrine.

If chloroform—C H Cl^3—be submitted to the action of heat, another chloride of hydrogen is formed, an equivalent of chlorine and an equivalent of carbon are set at liberty. This proceeds from the reaction indicated by the formula

$$C H Cl^3 = Cl^2 H + Cl + C.$$

M. Moigno has established that pure chloroform, free, more particularly, from any trace of alcohol, does not burn. He has established, besides, that pure chloroform, mixed with inflammable liquids, destroys their inflammability. His experiment was an easy one to perform, and began by mixing petroleum and chloroform in the proportion of five parts of the former to one of the latter. This mixture will not burn with a wick. It is both uninflammable and incombustible, until, that is, the greater portion of the chloroform has been volatilized. To give the experiment greater effect it may be varied in its operation, as follows:—Let a litre of petroleum be spread over a surface of 10^{qc}, set the liquid alight, and when it has well taken, pour 50 cubic centimetres of chloroform into the mass. The petroleum is at once extinguished. If now an attempt be made to rekindle the petroleum by any inflamed body, the latter goes out on touching the mixture.

The discoverer of this curious property of chloroform, extending the scale of his experiments, next poured four litres of petroleum upon this same surface—10^{qc}. This liquid mass, having a depth four times that of the amount first experimented on, was well lit, and was then successfully extinguished by the same quantity of chloride of hydrogen as before—50 cubic centimetres.

M. Moigno then proceeded—1. To raise the vapours of explosive gases. The greater number of these mixtures lost their inflammability. 2. To expose a wick saturated with chloroform to a strong flame of alcohol. The flame became smoky, and an intensely opaque vapour of hydrochloric acid—H Cl—was formed. 3. To pass the vapour of boiling chloroform into a good flame of alcohol. The flame is extinguished.

Practically, what can one make of these experiments? Less, perhaps, can be made of them in the way of process than in that of principle. They point to the possibility of the extinction of the obstinate and dangerous flame of burning petroleum.

The principal difficulty in this application of chloroform will consist in its high price, chloroform costing fron ten to fifteen francs the kilogramme. This difficulty will, doubtless, prevail against the adoption of the new principle for the extinction of petroleum fires in large towns, where less costly means are at hand, but it will not hinder its adoption in a case considered till now almost beyond the reach of help—fire on board ship. In this direction M. Moigno thinks there is fair room for experiment, and reasonable ground to hope for satisfactory results. If the indications given by laboratory experiments lead to good practical results, an important problem will have been solved. It is not impossible to conceive that a ship could be furnished with a supply of chloroform, so stored as to admit of projection to any point where fire broke out. However considerable its first cost, this, as the chloroform keeps good from voyage to voyage, would be small for each one; and in presence of the terrible disasters it is capable of preventing, the question of cost disappears altogether.

I have only a few words to spare for the subject of the second part of my letter.

If powdered anthracite be mixed with a small proportion of tar, coal, turf, or other agglutinating material, we have, upon carbonization of the mixture, a product nearly resembling gas coke, and offering all its qualities. This product, which we may call anthracite coke, though made with anthracite that crackles in the fire, makes no noise itself.

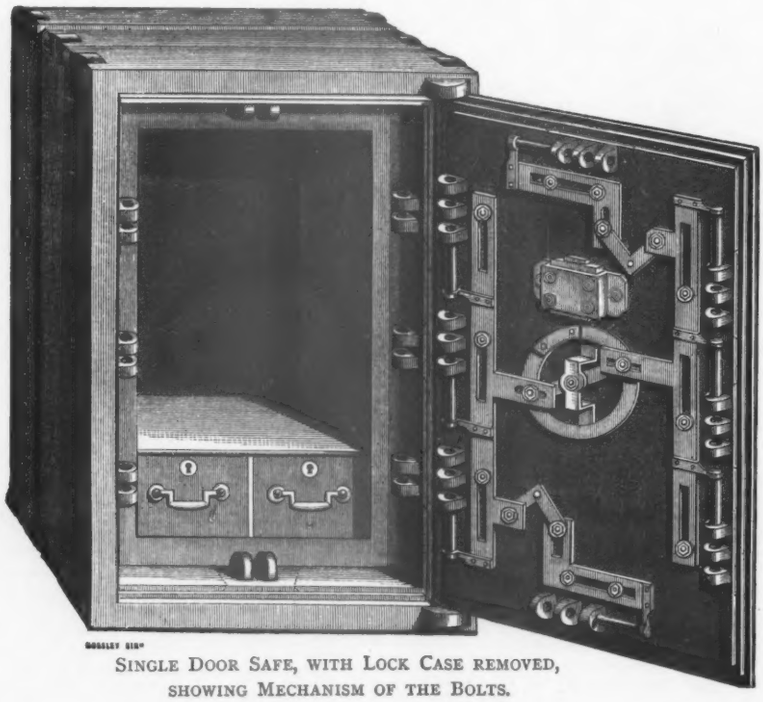
This anthracite coke can be made in ordinary ovens, but only

by using such a proportion of the agglomerating substances, that the gas from them will suffice for heating the oven,—*i.e.* a much large quantity than is required for the simple agglomeration of the mixture. M. Chavigné remedies this by his gas-generating oven.

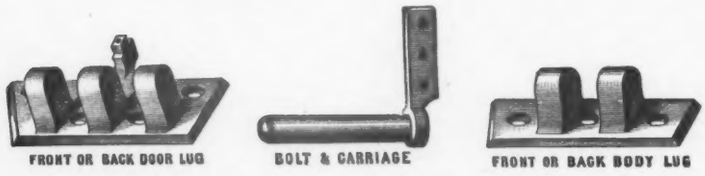
In the centre of a solid mass of masonry, in which may be placed some sixteen retorts in cast iron or refractory earth, or merely formed by brick partitions connected here and there with the masonry, is placed a gas-generator of any desired system in which wood, turf, lignite, combustible rubbish of any sort may be burnt. At each corner of the kiln is a chimney furnished with a register, by which the draught, and consequently the temperature of each part of the oven, can be regulated.

These are the two new ideas I promised to bring before you. The latter is an actuality. M. Chavigné's ovens are at work at Terre-Noire, in the department of the Loire. As to the first it permits advantages to be hoped for which every one must desire possible.

B. P.



SINGLE DOOR SAFE, WITH LOCK CASE REMOVED, SHOWING MECHANISM OF THE BOLTS.



THE "SICKER" DOUBLE GRIP-BOLT SAFES, &c.

OUR attention has recently been called to a new Fire and Thief Proof Safe, as supplied for use in the International Exhibition. The inventor and patentee is Mr. J. F. Elwell, of Birmingham. Besides availing himself of the most effective known protection against fire, and the best security against "drilling," the inventor has introduced an ingenious method of resisting the burglar's wedges or crowbars. His improvement essentially consists of an arrangement by which the door of the safe is so strongly secured to its body as to defy the "wedge." To each of the four sides of the door are attached a series of pierced knuckles or "lugs" of a similar character to the half of a butt hinge, and to the four sides of the inner frame of the safe are fixed corresponding pierced knuckles or "lugs." As the door is closed these knuckles unite, and by simply turning an outside handle, as an ordinary safe, bright steel bolts 6 in. long $\frac{7}{8}$ in. diameter, are simultaneously shot through the engaged pierced knuckles or "lugs." These vertical and horizontal bolts are carried by reins, geared together by cranked levers turning on centres. The bolts are shot and withdrawn by means of a centre wheel which communicates with the knob or handle outside. The spindle of the knob is carried by a cross bar on the wheel, and the wheel is connected with the vertical bolts by cross-bars or levers. When the door has been closed and the handle so turned as to shoot the bolts into the engaged knuckles, the wheel is fastened into its shot position by means of a patent lock or locks placed above or below it, whose bolts engage with stops or shoulders on the wheel. The knuckles or "lugs," which are of great strength, are each with their base plate one solid piece. The base plate is dovetailed and counter dovetailed, and is so inserted in slots in the door and frame that it cannot be wrenched or forced out of position. The obvious effect of the principle is by thus destroying all lever force to so hold the four sides of the safe to the door as to prevent the forcing away of the frame and thus releasing the bolts. To frustrate the operation of "drilling" the safes are constructed of two thick boiler plates intersected throughout with plates composed of iron and steel combined, which by a chemical process is so hardened as to render it perfectly impenetrable. The body is united by dovetailing and riveting on to an inner framework of angle iron.

Our illustration, showing the door of a safe with the fire-proof chamber removed, in order to lay bare the mechanism, will give the reader a clear notion of the arrangement. The principle is applicable to every kind of safe whether with one or two doors, and also to the doors of bankers' strong rooms.